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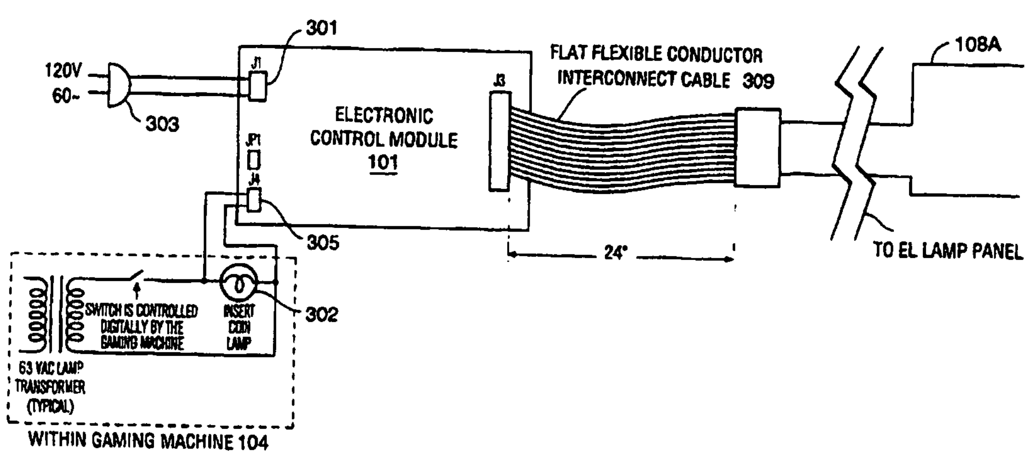

(57) Abstract

A retrofit lighting system (100), for use with a host machine (104), produces lighting effects in response to lamp power signals that are provided from the host system (104) and that would otherwise be used to power lamps (108) of the host machine (104). An EL lamp system (108) has a plurality of EL lamp cells. Sequencing circuitry (106) provides an EL lamp driving signal to independently control each of the EL lamp cells of the EL lamp system (108) such that the EL lamp cells collectively illuminate in a sequence corresponding to the EL lamp driving signal. The microcontroller (406) controls the frequency, amplitude, and duty cycle to the electroluminescent lamps (108). By changing the frequency, the microcontroller (406) alters the intensity and illumination color. By changing the amplitude, the microcontroller (406) alters the illumination intensity. Further, data signal lines are supplied from the microcontroller (406) to select which electroluminescent lamps (108) to illuminate, thereby creating animated displays. Signal conditioning circuitry (102) non-invasively samples the lamp power signals provided from the host system (104), and provides the driving signal to the EL lamp (108) in response thereto.

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Title: **Retrofit Lighting System that Non-Invasively Interacts with a Host Machine**

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Technical Field

The present invention relates to a lighting system that interacts with a host machine, such as a gaming machine. In particular, the present invention relates to a retrofit lighting system that interacts, preferably non-invasively, with a host machine and that illuminates with a sequence corresponding to a state indication sampled from the host machine.

Background

Many machines, such as vending machines and gaming machines, illuminate one or more light bulbs on the exterior of the machine in response to internal states of the machine. For example, a slot machine illuminates various incandescent light bulbs to illuminate its "paylines" depending upon the number of coins inserted into the machine.

However, incandescent light bulbs consume large amounts of power. Thus, it may be desired to replace the incandescent bulbs with electroluminescent (EL) lights, since EL lights consume less power. Electroluminescent (EL) lamps are light sources that contain a special

phosphor or combination of phosphors that luminesce when they are subjected to electric fields. Perhaps more significantly, it may be desired to modify the manner in which the lights are illuminated in response to the internal states of the machine. For example, the manner in which the lights are illuminated may be altered to draw people to the machine or to provide useful information.

Typically, much of the circuitry for controlling a machine's lighting system is incompatible with powering lower power light sources. In addition, the circuitry for controlling the manner in which the lights are illuminated is usually internal to the machine. As a result, it is expensive to modify the lighting system. This is especially so when the machine is a gaming machine, since state gaming laws require that gaming machines undergo extensive testing and certification after any changes are made to their internal circuitry.

In the past, EL lamps required high voltage electricity for them to operate. Because of this, bulky power supplies, inverters and/or other electronic circuitry and batteries (for cordless operation) are required to supply the appropriate electric power to cause the lamp to emit light. The power supply is usually a lot more bulky than the lamp.

Typical EL lamps are powered by high voltage (usually greater than 10 V) power supplies. These power supplies are frequently AC (Alternating Current) type supplies. Some ELs are powered directly from standard house current (typically 120 VAC). For battery rather than house current operation, usually an inverter or other circuit is required to step up and/or convert the battery's DC electricity to high voltage AC electricity.

An EL lamp display circuit may include a memory, an audio sequencer, and a counter to define segments of the EL display to be illuminated. Control of the output display in such a systems is restricted, however, by the limited data manipulation abilities of the memory and the counter. Because a fixed AC voltage wave generator drives the display, the

output is further restricted in that dynamic control of the color and intensity the output display is not possible.

Summary

The present invention is a retrofit lighting system, for use with a host machine, to produce lighting effects in response to lamp power signals that are provided from the host system and that would otherwise be used to power lamps of the host machine. An EL lamp system has a plurality of EL lamp cells. Sequencing circuitry provides an EL lamp driving signal to independently control each of the EL lamp cells of the EL lamp system such that the EL lamp cells collectively illuminate in a sequence corresponding to the EL lamp driving signal. In particular, the sequencing circuitry includes a microcontroller connected to a power supplying circuit for supplying a driving signal, the driving signal being of an appropriate magnitude and frequency to drive the electroluminescent display elements. A selection circuit receives a plurality of signals from the microcontroller and receives the driving signal from the power supplying circuit. The selection circuit selectively forwards the driving signal to each of the individual electroluminescent display elements based on the signals received from the microcontroller. By this arrangement, the microcontroller turns each of said display elements on or off in a sequence, thereby generating animated displays. Signal conditioning circuitry non-invasively samples the lamp power signals provided from the host system and that provides the EL lamp driving signal in response thereto.

The circuit may also include load capacitors that can be selectively switched by the controller to present capactive load to the drive signal generator in addition to the capacitive load presented by the elements of the electroluminescent panel. The load capacitors may not only address a "spiking" phenomona associated with switching the drive signal from one element to another element, but may also provide compensation for differing

capactive loads that result from different size elements being driven at different points in the sequence.

Brief Description of the Drawings

Fig. 1 is a block diagram illustrating a retrofit lighting system 100 in accordance with an embodiment of the invention.

Fig. 2 illustrates a gaming machine with which the retrofit lighting system 100 shown in Fig. 1 may be used.

Fig. 3 illustrates how the retrofit lighting system interfaces to the gaming machine in accordance with an embodiment of the invention.

Fig. 4 is a top-level schematic diagram illustrating an embodiment of a circuit for controlling one of the EL lamp systems of the retrofit lighting system 108 of Fig. 1.

Fig. 5 is a schematic diagram illustrating the drive signal generator of the Fig. 4 schematic in greater detail.

Fig. 6 is a schematic diagram illustrating the switching circuits of the Fig. 4 schematic in greater detail.

Fig. 7 is a schematic diagram illustrating the microcontroller (and associated glue logic) of the Fig. 4 schematic in greater detail.

Fig. 8 is a graph that illustrates a spiking phenomena may occurs when the switching circuits are switched in a first sequence.

Fig. 9 is a graph that illustrates a second switching sequence, and employing load capacitors, to address the spiking phenomena.

Fig. 10 is a high level conceptual block diagram of an EL controller according to a further embodiment of the present invention;

Fig. 11 is a detailed block diagram of an EL controller according to the embodiment of Fig. 10;

Figs. 12A through 12D illustrate microcontroller pulse signals and EL panel driving signals;

Fig. 13 is a block diagram of an EL controller according to a still

further embodiment;

Fig. 14 is a detailed block diagram of the high voltage driver of the EL controller of Fig. 13;

Fig. 15 is a timing diagram illustrating an exemplary timing sequence in the EL controller of Fig. 13;

Fig. 16 is a block diagram of an EL panel multiplexing circuit; and

Fig. 17 is a block diagram of a still further embodiment of the EL panel controller device.

Detailed Description

Fig. 1 illustrates, in block form, a retrofit electroluminescent (EL) lighting system 100 in accordance with an embodiment of the present invention. The EL lighting system consumes less power than incandescent bulbs of a host machine that are otherwise used. Alternately, even if the incandescent bulbs are used, the EL lighting system 100 can provide additional lighting effects with a minimal amount of additional power. By retrofitting a machine with the retrofit EL lighting system 100, it is quite easy to modify the manner in which lights are illuminated in response to the internal states of the machine.

In the embodiment illustrated in block form in Fig. 1, the system 100 includes three EL lamp panels 108a, 108b, and 108c (generically referred to herein as 108). Each EL lamp panel 108 includes a plurality of independently drivable EL lamp cells. The panels are driven by an electronic control module 101. Each panel is driven by a separate sequencing sub-circuit seq1, seq2 and seq3, respectively, of the electronic control module 101 and included in a sequencing circuit 106. For example, as shown in Fig. 2, if the gaming machine 104 is a slot machine, the lamp panels 108a, 108b and 108c are suitable for being located on the "top glass" 152, "reel glass" 154 and "belly glass" 156 of the slot machine 104. An additional area of the slot machine 104, designated in Fig. 2 by numeral 158, may be provided with an

EL panel to draw attention to the "bill collector" function of the slot machine 104.

Each lamp of an EL panel turns on when an alternating driving current or pulsed direct current is supplied to the lamp. The intensity of the lamp varies depending upon the magnitude and the frequency of the lamp driving current, while the color of the lamps varies depends on, for example, the frequency of the driving current.

Fig. 3 illustrates how the retrofit lighting system 100 interfaces to the gaming machine 104 in accordance with an embodiment of the invention. The electronic control module 101 includes a connector 301 for connecting (via a standard plug 303) to a standard 120V, 60 Hz alternating current power supply. In Fig. 3, a single state control signal is obtained from the gaming machine 104 for controlling the EL panel 108a, to be located on area 158 of the slot machine 104. More specifically, signals generated by the gaming machine 104 indicate an internal state of the gaming machine 104, and these state indication signals are preferably sampled non-invasively by circuitry within the electronic control module 101. That is, the state indication signals are preferably sampled without affecting the internal state of the gaming machine 104.

For example, a power signal provided from the gaming machine 104 to power an external incandescent bulb may be utilized as the state indication signal. The power signal would be sampled by tapping into the power signal where it is provided to the incandescent bulb. An example of this is shown in Fig. 3, where the power signal provided by the gaming machine 104 to an "insert coin lamp" 302 is sampled, and provided to the electronic control module 101 via a connector 305. As another example, the machine's original bulb may be left in place and a photo-sensor employed to determine when the light bulb is illuminated. A problem with this is that the original bulb may burn out. As yet another example, a coil may be provided surrounding the wire that provides the power signal to the bulb and the magnetic field

generated by current in the wire measured by the coil and utilized as the state indication signal. In each case, the goal is to non-invasively sample the power signal to the bulb. (Alternately, but non-optimally, a state indication signal could be provided directly from the microcontroller or other circuitry of the gaming machine 104.)

In response to the state indication signal provided from the gaming machine 104, the electronic control module 101 generates lamp panel driving signals for driving one of the EL lamp panels (in this case, EL panel 108a shown in Fig. 1). As shown in Fig. 3, the lamp panel driving signals are provided to the EL lamp panel 108a from the electronic control module 101 via an interconnect cable 309. The lamp panels are commercially available from MKS of Bridgeton, New Jersey.

Electroluminescent (EL) lamps come in a number of forms, in addition to EL panels, such as EL lamp threads or filaments. The lighting system may include any of these forms of EL lamps. An EL panel is an EL lamp strip on a backing sheet. The EL panels are preferably made by selective deposition of a phosphor compound and selective deposition of conductive rear electrodes (e.g., polymer materials containing high loadings of silver particles). Multiple sections of this phosphor-electrode arrangement can be deposited on the panel to form patterns. Each section is individually connected to a power supply, so that they may be independently turned on or off, thus facilitating animation. Although the present embodiments are described referring to EL panels, single or multiple EL lamp filaments may easily be substituted for the EL panels.

A detailed embodiment of the electronic control module 101 is now described with reference to Fig. 4 through 7. Fig. 4 is a top-level schematic diagram that shows a more detailed embodiment of the electronic control module 101 than is shown in Fig. 1. As shown in Fig. 4, the electronic control module 101 is for causing selective illumination of the cells of the EL lamp panel, in an animated sequence, at the area 158 of the slot machine 104.

Referring still to Fig. 4, host machine interface circuitry 102 receives the state indication signal (e.g., a sample of the power signal used to power an incandescent light bulb) from the gaming machine 104 and conditions the sampled signal as appropriate (e.g., by shifting the level of the sampled signal) for input to a microcontroller 406. The details of the conversion are dependent upon the particular gaming machine 104 and, more particularly, the level of the sampled signal.

The conditioned state indication signal is provided to the microcontroller 406 via an opto-isolator 404 or 405). The opto-isolators 404 or 405 isolate the electronic control module 101 from the gaming machine 104 so that the gaming machine 104 internal circuitry is protected from being affected by glitches that may develop in the electronic control module 101 (e.g., as a result of a shock caused by a release of static electricity from a player of the game machine 104). If the electronic control module 101 is connected directly to the internal electronics of the gaming machine 104, it is likely that any electro-static discharge to the electronic control module 101 will be directly coupled into the gaming machine 104, disrupting its process and resulting in a "hopper" dump.

A drive signal generator 408, powered by a power supply 410, provides a sinusoidal driving signal for driving the EL cells via EL drivers circuitry 412 and ultimately via the pins of connector 416. As described in appl. no. 08/591,014, incorporated by reference above, the microcontroller 406 selectively enables switching circuits within the EL drivers circuitry 412 in response to the conditioned state indication signal to cause the switching circuits to selectively provide drive signals to the EL cells. (The switching circuits are described later with reference to Fig. 6.) As a result, the EL cells are illuminated in an animated sequence. Microcontroller 406 is connected to inverter 408 via an ENABLE-H signal. By asserting the ENABLE-H signal, microcontroller 406 can disable drive signal generator 408 from providing the driving signal.

The details of the drive signal generator 408 in accordance with one embodiment of the invention is shown in greater detail in Fig. 5. An inverter 502 provides the sinusoidal driving signal. The capacitors C6 and C6A provide a load capacitance that limits the maximum output voltage from the inverter 502.

A low voltage monitor 504 monitors the amplitude of the sinusoidal driving signal provided from the inverter 502. Specifically, when EL lamps/cells fail, they typically develop either direct and/or partial shorts. This can severely overload the inverter 502, as it tries to supply a sufficient current to drive the shorted EL cell. The low voltage monitor 504 is a voltage comparator circuit. It converts the sinusoidal output of the inverter 502 to a DC voltage that is proportional to the inverter 502 output voltage. When an EL cell shorts and the inverter 502 output drops below the value set by resistors R11, R12 and R13, the output of the low voltage comparator 504, LVOLT-H, is asserted. The LVOLT-H output is optically coupled to the microcontroller 406. The microcontroller 406 is programmed to monitor the LVOLT-H signal and, upon detecting that the LVOLT-H signal has been asserted, disable the inverter 502. This prevents excess currents, which would be drawn through the inverter 502, from causing permanent damage to the inverter 502.

A zero crossing detector 506 may be provided to detect when the drive signal provided from the inverter 502 crosses a zero voltage amplitude. When the zero crossing is detected, zero crossing detector 506 provides a ZEROX-E control signal to the RB1 input of the microcontroller 406 (Fig. 4). The microcontroller switches the switching circuits within EL drivers circuitry 412 to begin providing drive signals via connector 416 only when the drive signal provided from the inverter 408 has about a zero voltage amplitude. In this way, the EL cells can be protected from sharply increasing drive signal inputs (i.e., spikes). In addition to causing potentially annoying visual "flashes", such drive signal spikes may cause breakdown of the

capacitance within the EL cells and render the EL cells inoperable.

A portion of a detailed embodiment of the EL drivers circuitry 412 is now described with reference to Fig. 6. In particular, the EL drive signal generated by the drive signal generator 408 is provided to an AC HOT input of the EL drivers circuitry 412. Each of a plurality of switching circuits 602a through 602i includes a switch control input (RC0 through RC7 and RB7, respectively) and a drive signal output (DRC0 through DRC7 and DRB7, respectively). Each of the switching circuits 602a through 602i is also connected to receive the AC HOT input to receive the EL drive signal generated by the drive signal generator 408. The switching circuits 602a through 602i include four rectifier diodes and one bipolar junction transistor.

In response to a program being executed by the microcontroller, the microcontroller asserts various ones of its switch control outputs, RC0 through RC7 and RB7, connected to the switch control inputs, RC0 through RC7 and RB7, respectively, of switching circuits 602a through 602i, respectively. In response, when the switch control input of a particular switching circuit is asserted, that switching circuit passes the drive signal from AC HOT to the output of the switching circuit. Referring back to Fig. 4, it can be seen that each of the switching circuits 602a through 602i is connected, via connector 4016, to a separate one of the EL cells of the "bill collector" EL panel located at area 158 of the gaming machine 104 (Fig. 2).

Referring still to Fig. 6, the supplemental switching circuits 604a and 604b are now discussed. The supplemental switching circuits 604a and 604b respond to switching signals provided from switch control outputs RB5 and RB6 of the microcontroller 406 to switch control inputs RB5 and RB6, respectively, of supplemental switching circuits 604a and 604b, respectively. Specifically, the supplemental switching circuits 604a and 604b passes the drive signal from AC HOT to the output DRB5 and DRB6 of the supplemental switching circuit, 604a and 604b, respectively, whose switch control input RB5 and RB6, respectively, is asserted. The drive signal, via

outputs DRB6 and DRB7, to load capacitors C7 and C7A or to load capacitors C8 and C8A, respectively.

The reasons for providing the drive signal to load capacitors C7 and C7A or to load capacitors C8 and C8A is now discussed. The inverter 502 (Fig. 5) of drive signal generator 408 is both load dependent and self-compensating. (In a preferred embodiment, the inverter 502 is an "NS" series inverter provided by NEC.) That is, the inverter 502 includes circuitry such that the frequency of the sinusoidal driving signal that the inverter 502 provides is determined by the capacitance of the load being driven at any particular point in a lighting sequence (nominally, the load of the EL cell or cells being driven via the particular one or ones of the switching circuits, of EL drivers circuitry 412, that is selected to provide a drive signal). In addition, the capacitance of an EL cell changes as the EL cell ages. The inverter 502 senses the capacitance change and adjusts the frequency of the driving signal generated such that the EL cell is illuminated at a relatively constant brightness even as its capacitance changes.

Since the capacitance load of an EL cell is largely determined by its size, when the plurality of EL cells being driven in a sequence by the single inverter 502 are different sizes, the frequency of the sinusoidal driving signal provided by inverter 408 will fluctuate depending on the size (and, thus, capacitance) of the EL cell (or combinations thereof) being driven. As a result, if no accommodation is made for the differing loads presented by different combination of EL cells, the brightness with which each EL cell is illuminated will fluctuate widely in comparison to each other. This phenomena is visually unappealing.

However, by adding the load capacitors C7 and C7A or to load capacitors C8 and C8A to the capacitive load experienced by the inverter 502, the inverter 502 experiences a substantially constant capacitive load throughout the illumination sequence. By maintaining the substantially constant capacitive load, the frequency of the sinusoidal drive signal provided

by the inverter 502 can be maintained substantially constant. As a result, the brightness with which the EL cells are illuminated during the sequence is maintained at each time point in the lighting sequence. This allows the inverter 502 to "sense" the capacitance change for each particular EL cell, due to aging, and compensate for it.

The number of supplemental switching circuits and load capacitors, the capacitance values of the load capacitors, and the arrangement of load capacitors required to even out the capacitance load on inverter 502 depends upon the variation in sizes of the EL cells being driven and the desired percentage tolerance of brightness variations. A sequence of switching supplemental switching circuits, to include the load capacitors in the load experienced by inverter 408, can be predetermined and included in the sequencing program executed by microcontroller 406. That is, in addition to controlling the switching circuits within the EL drivers circuitry 412 to illuminate the EL cells, the microcontroller 406 can also be pre-programmed to control the supplemental switching circuits to selectively cause various ones (or combinations) of load capacitors to load inverter 502 as a function of which one or ones of the EL cells is illuminated.

In the embodiment shown in Fig. 4, capacitors C8 and C8A together have an effective capacitance of .01 μF and capacitors C7 and C7A together have an effective capacitance of .022 μF. Thus, there are four variations of load capacitance which can be achieved by selectively enabling DRVR #A and DRVR #B, as shown below:

DRVR #A	DRVR #B	TOTAL "ADDITIONAL" LOAD
DISABLED	DISABLED	0.0 μF
ENABLED	DISABLED	0.01 μF
DISABLED	ENABLED	0.022 μF
ENABLED	ENABLED	0.032 μF

The actual values for the load capacitors and their configurations may be determined qualitatively (i.e., by experimenting with different values and qualitatively reviewing the resulting illumination sequence). Preferably, however, the surface areas of the EL cells being driven during the illumination sequence can be quantitatively correlated to an equivalent capacitance. A memory (e.g., a read-only memory) may be provided. A table in the memory includes a plurality of table entries, each table entry corresponding to a step of the lighting sequence and indicating which load capacitors to switch on during the corresponding step of the sequence.

Fig. 7 schematically illustrates an embodiment of the microcontroller 406 and associated glue logic.

Fig. 8 illustrates a phenomena by which, if the microcontroller 406 turns off the switching circuit (i.e., one of 602a through 602i) corresponding to a first EL cell (referred to as "CELL #1" in Fig. 8) a short time (even as short as a few microseconds) before turning on the switching circuit corresponding to a second EL cell (referred to as "CELL #2" in Fig. 8) and the sinusoidal drive signal generated by the inverter 502 is at a peak, then the drive signal may spike (to greater than 400 V) due to the sudden decrease in capacitive load and potentially damage either or both of the inverter 502 and EL cell #2.

Fig. 9 illustrates how the spike in the drive signal can be avoided even without using the zero-crossing detector 506. First, the switching circuit corresponding to CELL #2 is switched on before the switching circuit corresponding to CELL #1 is switched off. Before switching on the switching circuit corresponding to CELL #2, the switching circuit (or circuits) corresponding to a load capacitor (or capacitors) is switched on. The places a large capacitive load on the inverter 502 such that a spike will not occur when the switching circuit corresponding to CELL #2 is later switched on (e.g., 0 to 5 μs after the switching circuit corresponding to the load capacitor is switched on. Finally, after enough time has passed for the load on the

inverter 502 to stabilize (e.g., about 100 μs), CELL #1 is switched off.

Appendix A is a source listing of assembly language code that may be executed by the microcontroller 406 to execute a sequence.

In a fully integrated driving circuit, a microcontroller may control not only the switching on of each lamp, but also the intensity of the lamp, and the color of the lamp. The microcontroller 406 can be used to create animated displays on all sorts of one, two, and three dimensional light emitting objects. Examples of such objects include clothing, works of art, molded parts, and informational displays. In clothing, for example, electroluminescent threads can be used for animated logos, designs, or other accents.

A conceptual block diagram of a further embodiment of an EL panel controller device is shown in Fig. 10. In this embodiment, microcontroller 1100 controls the color, intensity, and switching sequence of a plurality of EL lamps 1102. An EL driver 1106 supplies an alternating current to the EL panels under the control of the microcontroller 1100. A plurality of solid state switches 1104 connect the EL driver 1106 to the EL panels 1102. I/O pins 1110, labeled 1 through n of microcontroller 1100 output control signals to control lines of the switching circuits 1104. Switching circuits 1104 control the circuit of electrical energy flowing through EL driver 1106 and EL panels 1102.

Control lines 1108 are optional. If installed, control lines 1108 connect the microcontroller 1100 to the EL driver 1106. Through control lines 1108, the microcontroller 1100 controls the frequency and magnitude of the current output by the EL driver 1106. The frequency, the duty cycle, and intensity of the output of the driver 1106 will determine the color and intensity of the individual EL lamps 1102.

A more detailed block diagram of the EL panel controller of Fig. 10 is shown in Fig. 11.

The microcontroller 1100 preferably has a low cost and a low

peripheral component count. A commercially available microcontroller such as the PTC16C55 or the PIC16C57 from MICROCHIP could be used as microcontroller 1100. Any suitable microcontroller or microprocessor, however, could be substituted in its place.

A voltage regulator 1202 connects the battery to the microcontroller 1100 and regulates the voltage from the battery to the level required to power the microcontroller 1100. In this example, regulator 1202 supplies the microcontroller 1100 with 5.0 volts DC.

A timing circuit 1204, such as a ceramic resonator or quartz crystal (XTAL), resistor, and/or capacitor(s), is connected to provide timing signals to the microcontroller 1100. Variations on this embodiment containing an on-board timer in microcontroller 1100 may not require a timing circuit.

Push-button(s) 1206 are connected to the microcontroller to allow a user to control functions of the microcontroller such as on/off, pattern select, color, and output timing adjustment.

The EL driver circuit 1106 is composed of an oscillator (or function generator) 1208, a power amplifier 1210, and a transformer 1212. The transformer 1212 connects the oscillator 1208 and the power amplifier 1210 to the output of the EL driver circuit 1106 (Fig. 10). The power amplifier 1210 receives the output of the oscillator 1208. This signal is then amplified by power amplifier 1210 and drives the primary winding of the transformer 1212. The oscillator 1208 may supply, for example, sinusoidal, square, or sawtooth waveforms. A typical driving signal transmitted from the transformer 1212 may be, for example, a sinusoidal signal with a frequency of 1000 Hz and an amplitude of 35 volts.

The type and frequency of the waveforms output from the oscillator 1208 may be controlled by the microcontroller 1100 through control line(s) 1214. Similarly, the amplification of the power gain 1210 may be controlled by the microcontroller 1100 through control line(s) 1216.

Changing the frequency of the driving signal for an EL lamp affects

the color and the intensity. Color swings from lime green or deep green to a blue or purple color are possible solely by altering the frequency and the duty cycle of the driving signal. This corresponds to a shift of approximately 150 nm in the visible light spectrum.

Changing the amplitude of the driving signal affects the intensity. The perceived intensity may also be altered by adjusting the duty cycle of the switching signals (explained below).

Switching circuits 1104, connected to and controlled by I/O pins 1110, connect their respective EL panels 1102 to the EL driver 1106. Switching circuits 1104 each contain a high-voltage transistor 1218. The base of each transistor 1218 is connected to a resistor 1220 which is connected to the microcontroller 1100. The emitter of each transistor 1218 is connected to ground, and the collector of each transistor 1218 is connected to diode bridge 1222. Each EL panel 1102 is connected between one of the diode bridges 1222 and one end of the secondary winding of the transformer 1212.

Switching circuits 1104 are duplicated for each EL panel controlled by an I/O pin of microcontroller 1100. The number of circuits 1104 is limited by the number of output pins available on the microcontroller 1100, although, of course, not all of the output pins have to be used.

In operation, the embodiment of Figs. 10 and 11 functions as follows.

Microcontroller 1100 controls the switching circuits 1104 through I/O pins 1110. A high output ("1") on any of the I/O 1110 closes the switching circuit, which allows EL driving current to flow through the switch's corresponding EL panel 1102, illuminating the lamp. A low output ("O") on any of the I/O pins 1110 opens the switching circuit, which inhibits EL driving current flow through the switching circuit's corresponding EL panel 1102, causing the switch to turn off. Specifically, in reference to Fig. 11, a high output ("1") causes current to flow through the resistor 1220 which turns on the transistor 1218. This allows current to flow through the transistor 1218, the diode bridge rectifier 1222, and the EL panel 1102, thereby

illuminating the EL panel. Similarly, a low output ("O") causes the EL panel to extinguish.

If control lines 108 are implemented, microcontroller 1100 controls the frequency and amplitude of the driving voltage output by EL driver circuit 1106. In this manner, microcontroller 1100 controls the color and intensity of the EL panel output display.

The push button(s) 1206 can be used execute microcontroller on/off, pattern select, and timing. For example, tapping the button once will turn the controller on for a predetermined period of time after which the controller may execute a sleep instruction and, in essence, turn itself off. Pressing the push button 1206 a second time before the sequence has ended commands the display to display continuously. Pressing the push button 1206 a third time stops the display and reset the controller into standby mode. An indicator light can be used to flash the present state of the controller.

Microcontroller 1100 uses its I/O pins 1110 to control the state (i.e., on or off) of each EL panel to output a sequence corresponding to a preprogrammed animation sequence to be displayed on the EL panels. When the microcontroller outputs the next word in the animation sequence to its I/O pins, the EL panels change to a state corresponding to the new pattern. In this manner, preprogrammed display sequences are displayed on the EL panels.

Since each of the EL panels is coupled to an I/O pin on the microcontroller 1100, a complete state of the EL panels is defined when the microcontroller 1100 places an output on each I/O pin 1110 coupled to an EL panel. Animation of the EL panels is achieved by continuously updating the state of the I/O pins, 1110 outputs.

Two software approaches have been used to time sequence the I/O pins' 1110 patterns. The first approach is to construct a table of words, encoded as part of the microcontroller programming, that define the state of all the panels for each step in the sequence. For example, a three step

sequence might be: all panels on, every other panel on, all panels off. If 15 EL panels are used, this is represented by the table of states:

11111111 1111111
10101010 1010101
00000000 0000000

The microcontroller 1100 simply outputs the first line in the table to the I/O pins 1110, turning all of the EL panels on. After waiting a predetermined period, microcontroller 1100 transmits the next line in the table to the I/O pins 1110, turning every other EL panel off. After another predetermined delay, the last line is transferred, turning all of the EL panels off.

A second sequencing approach involves initializing the states of the I/O pins 1110 and then computing subsequent states based on the previous states and a selected bit manipulation function. For example, a "chase" pattern could be executed by initializing the states of the I/O pins 1110 to:

10111111

and then executing a rotate right instruction on this port. The next output sequence would then be:

11011111

The bit manipulation function used may be any combinatorial or sequential function executable by the microcontroller 1100. The approach has the potential advantage of saving memory space by reducing the table size required to hold needed states.

A common problem in the prior art associated with EL lamps is that when the lamps are driven for an extended period of time at a high frequency, they emit heat, and may eventually burn out. The heating problem can be alleviated with the present invention by either having the microcontroller periodically turn the hot EL panel off or, if the EL panel is to be on for an extended period of time, the on signal can be pulsed.

Figs. 12A and 12D illustrate pulse signals from microcontroller 1100 for controlling switching circuit 1104. These signals can be generated by microcontroller 1100 as a sub-signal of an EL panel 1102 on-period, or

equivalently, external circuitry could be used to pulse an on signal from the microcontroller 1100.

The human eye has a retentivity such that a light flashing faster than about 60 Hz is not perceived as flashing. Because of this, as long as the frequency of the on signal from I/O pins 1110 is pulsed at least at 60 Hz, the illuminated EL panel will appear to be continuously on.

Fig. 12A illustrates a 50 percent duty cycle pulse signal flashing at 60 Hz. During the high ("on") periods, the high frequency signal from the transformer 1212 (shown in Fig. 12B) is passed through switching circuit 1104, which are controlled by pulse signal 12A. The resultant signal (shown in Fig. 12C) drives the EL panel 1102, thus illuminating it. Even though the EL panels may be being driven at a much higher frequency from the driver 1106, they are only actually driven half the time because they are not driven when the pulse signal in Fig. 12A is low. This significantly reduces undesirable heating of the EL panels.

Because the pulse signal in Fig. 12A is generated by the microcontroller 1100, the duty cycle can easily be changed. An illustration of a 75 percent duty cycle pulse signal flashing at 60 Hz is shown in Fig. 12D. Changing the duty cycle of the pulse signal allows one to vary the Perceived intensity of the emitted light. For each complete period of the pulse signal in Fig. 12D, three quarters of the driving signal in Fig. 12B would get passed to the EL panels 1102 because the signal is on three-quarters of the time and off one-quarter of the time. Because the human eve is not completely linear with respect to duty cycle and perceived intensity, the 25 percent increase in the duty cycle between Figs. 12A and 12D will be perceived by an observer as slightly less than a 25 percent intensity increase.

The above described novel EL panel controller device may be packaged as a small, light, fully integrated unit. Further, dynamic control of color, intensity, perceived intensity, and heat dissipation for multiple EL panels or filaments is possible, thus allowing for a wide range of animation

capabilities.

A block diagram of a further embodiment of the EL panel controller device of the present invention is shown in Fig. 13. In this embodiment, EL Panels 1412 are connected to high voltage driver 1410. Three EL Panels are shown here for illustrative purposes, more or less could easily be used. Further, instead of using three separate panels, a single panel divided into multiple sections could equivalently be used.

Microcontroller 1400 receives power from voltage regulator 1404, which is in turn connected to battery 1406. Switch(es) 1402 connect to microcontroller 1400 and can be used for various control functions such as on/off, pat tern control, timing control etc. Voltage regulator 1408 is a high voltage regulator for providing power to the high voltage driver 1400. Typically, 200 volts is provided to driver 1410, although depending on the particular lighting requirements of there EL cases, a significantly higher or lower voltage may be used.

In operation, microcontroller 1400 controls the illumination of the EL Panels 1412 through driver 1410 using an output enable ($\bar{O}\bar{E}$) line, a polarity line, a data line, and a clock line. The data line is preferably a single line which serially loads data into a shift register contained in the driver 1410. For applications that require a faster load time, more data lines may be used.

Fig. 14 is a detailed block diagram of the high voltage driver 1410. Driver 1410 contains a shift register 1500. The shift register 1500 receives information from the data line in synchronism with the clock. Other shift register input lines, such as a register clear line or a shift register direction control line, although not shown, may also be input to the shift register 1500 from microcontroller 1400.

Data output from shift register 1500 is input to logic circuits 1502. Based on the output enable signal, the input from the shift register 1500, and the polarity signal, the logic circuits 1502 open or close MOSFETS 1504, 1506. Depending on the states of their MOSFETS, the EL Panels 1412 will

charge or discharge, causing them to illuminate.

In operation, microcontroller 1400 transmits the clock, polarity, and output enable signals to each logic circuit 1502 in high voltage driver 1410. The clock and data signals are serially input to shift register 1500. Shift register 1500 shifts data synchronously with the clock signal from the first segment to the second segment and finally to the third segment. At any given time, the microcontroller 1400 controls the shift register 1500, data and clock signals so that only a single "1", or ON bit, is present in the shift register 1500. A "1" in one of the three positions in the shift register 1500 corresponds to a potential ON state of its corresponding logic circuit 1502. At each clock pulse, the "1" is shifted down the shift register 1500. In this manner, the microcontroller 400 can control the EL panel 1412 to be activated. A "O", or OFF bit, corresponds to a potential OFF state in the corresponding logic circuit 1502. When in the OFF state, the logic circuits 1502 turn off the MOSFETS 1504 and 1506, thus presenting a high impedance state to its EL Panel 1412.

The $\bar{O}\bar{E}$ signal is an active low line. When this line is low, the logic section 1502 corresponding to the "1" in the shift register 1500 either charges or discharges its corresponding EL panel 1412, depending on the polarity signal. When $\bar{O}\bar{E}$ is high, all of the logic circuits 1502 control their corresponding MOSFETS 1504 and 1506 so that the EL panels 1412 see a high impedance state at high voltage driver 1410. In this state, none of the panels 1412 appreciably discharge or charge.

The polarity line is used to select the polarity of the charge experienced by the selected panel 1412 (i.e., the panel that has a corresponding "1" in the shift register). The EL panels 1412 emit light only when they undergo a change in potential. When a panel is selected by a "1" in the shift register and the output enable is enabled, the panel is charged if the polarity is high by turning MOSFET 1504 on and MOSFET 1506 off, or discharged if the polarity is low by turning MOSFET 1504 off and MOSFET

1506 on. Because the EL panels 1412 store the charge inputted from the DC voltage source (they act like capacitors), the microcontroller 1400 preferably alternates the polarity line between successive selections of an EL panel.

Fig. 15 is a timing diagram, illustrating the interaction of the clock, data, polarity, and output enable signals. Timing intervals t1 through t3 are labeled horizontally across the top of Fig. 15. In interval t1, data signal "1" is preferably loaded into the first segment of shift register 1500 on the rising edge of the clock. Because the output enable is disabled, all of the MOSFETS 1504, 1506 are off (high impedance state). At this point, EL panels 1412 effectively "see" open circuits when looking into driver 1410. This means that none of the EL panels 1412 are charging or discharging.

At time interval t2 the data signal is low, so the shift register 1500 shifts the previously loaded "1" to the second segment. The output enable is again disabled, therefore all of the MOSFETS 1504, 1506 are off.

At the beginning of t3, the output enable is enabled. The "1" in the shift register 1500 second segment is now latched into its logic circuit which then turns one of MOSFETS 1504, 1506 on. The MOSFET to be turned on is determined by the polarity signal. In this example the polarity signal is now high, which corresponds to turning MOSFET 1504 on. This allows current to flow from the power source to the middle EL panel, causing it to charge and emit light. The next time the microcontroller activates the middle EL panel, it will do so with the polarity signal low. This will clause MOSFET 1504 to go off and MOSFET 1506 to go on, allowing current to flow from the EL panel and causing it to emit light.

The clock signal controls the frequency at which the driving circuit 1410 is operated. Because the clock signal is controlled by the microcontroller 1400, its frequency and duty cycle can easily be varied by the software controlling the microcontroller. Typical operating frequencies may range from 100 Hz to 2000 Hz. Changing the frequency of the clock signal affects the intensity and the illumination color of the EL panels in a manner

similar to that in the Fig. 10 embodiment.

By controlling the clock, data, polarity, and output enable lines in a pre-programmed sequence, the microcontroller 1400 controls the EL panels color, intensity, and state, thereby producing animated visual displays.

A block diagram of a still further embodiment of the EL panel controller device of the present invention is shown in Fig. 17. In this embodiment, EL panels 1806 are connected to high voltage driver 1800. High voltage driver 1800 is located in a circuit similar to that of high voltage driver 1410 shown in Fig. 13. In this embodiment, however, data lines 1802a through 1802n are input from the microcontroller 1400 instead of the $\bar{O}\bar{E}$, polarity, and clock of the Fig. 13 embodiment. Solid state switching circuits 1804a through 1804n are controlled by data lines 1802a through 1802n respectfully and connect EL panels 1806 to either a high DC input voltage or to ground.

In operation, a high ("1") value on data line 1802a causes the solid state switching logic 1804 to connect its corresponding EL panel to the high DC voltage, charging the EL panel and causing it to emit light. When the microcontroller 1400 changes the value on input data line 1802a to a low ("0") value, the solid state switching logic 1804a connects its corresponding EL panel to ground, discharging it and causing it to emit light.

Alternatively, instead of having the microcontroller independently control both the charging and discharging of the EL panels 1806, additional circuitry could be implemented in the solid state switching circuits 1804a through 1804n to detect a change in the value of the data control lines from a low to a high value. When the change is detected, the solid state switching circuit will then automatically pulse the high voltage to the EL panel 1806. This is advantageous to the operator because he does not have to concern himself with programming the microcontroller to alternatively charge and discharge the EL panel, since this is automatically performed by the switching circuits 1804a through 1804n.

Fig. 16 illustrates a multiplexing circuit for simulating one EL panel by alternatively switching between two panels. Alternating switch 1700 connects the EL panel 1702 driving power supply to one of the two EL panels. The switch 1700 periodically switches between panels so that neither panel is driven for an extended period of time. The switching action may be based on an external clock signal, an internal clock signal, or the power-in signal, depending on the particular application. By multiplexing the driving signal to the two EL panels as described above, two EL panels are used to simulate one panel driven at twice the frequency of either of the individual panels. At high driving frequencies, this has been found to significantly reduce EL panel heat generation and therefore increase the EL panel's lifetime. This multiplexing arrangement can be implemented in either of the embodiments previously described.

The apparatus and methods described above comprise preferred embodiments of the present invention. However, it will be apparent to those skilled in the art that various modifications and variations can be made in the method or apparatus of the present invention and in construction of the embodiments without departing from the scope or spirit of the invention. As a first example, the microcontroller 1400 may be used to dynamically control the voltage regulator 1408. This would enable the microcontroller to exert further control over the EL panel illumination intensity. As a second example, instead of the oscillator, power amplifier, and transformer sections used in the Fig. 10 embodiment, a conventional inverter design could be used, provided that the output stage is able to float with respect to the input power.

APPENDIX A

```
;****************************************************************
;
; Copyright 1996, Add-Vision Incorporated
;
; Filename:  BC9B15.SRC
;
; Program Function:  9 Cell sequence for #101-0002-00 Controller
;                    RB7 = steady burn cell, plus 8 cell fill starting
;                    with RC0, filling thru RC7
;
;
; PIC PIN/HARDWARE DEFINITION:
;
;                    NAME    FUNCTION                        PIC PIN #
;                            ----------------------------------------
;                    RA0     ** NOT USED **                    6
;                    RA1     INPUT, SPEED ("B" KEY)            7
;                    RA2     INPUT, MODE  ("A" KEY)            8
;                    RA3     INPUT, INSERT COIN                9
;
;                    RB0     INPUT, LVOLT-H                   10
;                    RB1     INPUT, ZEROX-E                   11
;                    RB2     ** NOT USED **                   12
;                    RB3     OUTPUT, SCOPE TRIGGER            13
;                    RB4     OUTPUT, ENABLE-L, INVERTER       14
;                    RB5     OUTPUT, .01UF LOAD CAP           15
;                    RB6     OUTPUT, .022UF LOAD CAP          16
;                    RB7     OUTPUT, "ARROW"                  17
;
;                    RC0     OUTPUT, "THIS"                   18
;                    RC1     OUTPUT, "$1"                     19
;                    RC2     OUTPUT, "$5"                     20
;                    RC3     OUTPUT, "$10"                    21
;                    RC4     OUTPUT, "$20"                    22
;                    RC5     OUTPUT, "$50"                    23
;                    RC6     OUTPUT, "$100"                   24
;                    RC7     OUTPUT, "BILLS"                  25
;
;****************************************************************
;
;
; RC CLOCK/XTAL  - 4.00 MHz
```

```
;
;****************************************************************

; Select device and set CONFIG register

        DEVICE  PIC16C55,RC_OSC,WDT_OFF,PROTECT_OFF

;Equates
pic54           =  1ffh         ; Define processor specific reset vectors
pic55           =  1ffh         ;
pic56           =  3ffh         ;
pic57           =  7ffh         ;

passon          =  1            ; # of passes to enable display
passoff         =  0            ; # of passes to blank display
totpass         =  passon + passoff

;Function registers are pre-defined when
;  using Parallax instruction set.

; General purpose registers
currentstate =  8           ; offset into state tables
speedptr        =  9        ; offset into speed table
tenms           =  10       ; keeps count of tens of milliseconds
inrega          =  11       ; copy of input port A
temp            =  12       ; general purpose scratch pad register
dowhat          =  13       ; general purpose scratch pad register
stout           =  14       ; used to hold value to be outputted to a
port during selftest
passcntr        =  15       ; used to count number of passes
keyflags        =  16       ; flags used to process key pad inputs
fiftymscnt      =  17       ; used to count 50 milliseconds
;not_used       =  18
; "     "
; "     "
;last_reg       =  31

;Bit flag defintions
carry           = status.0
restart         = keyflags.0
speedpend       = keyflags.1
modepend        = keyflags.2
```

```
icmodejmpr    = inrega.0
speedkey      = inrega.1
modekey       = inrega.2
insertkey     = inrega.3
low_volt      = RB.0
zerox         = RB.1
inv_enable    = RB.4
loadcap22     = RB.6
loadcap01     = RB.5

;Misc definitions
tenmsec       =  100        ; 10 mS/64 uS = 156.25  (256-156) = 100

;****************************************************************
;
; Initialize ports A, B, C & Timer 0.
;
        org     0

Initialize
        clr     wdt                     ; Kick the dog!
        mov     portb,#00000000b        ; Set levels low
        mov     !portb,#00000011b       ; Set RB7-RB3 as outputs, RB2-RB0 as
inputs.

        mov     porta,#00000000b        ; Set levels low
        mov     !porta,#00001111b       ; Set RA3-RA0 as inputs

        mov     portc,#00000000b        ; Set levels low
        mov     !portc,#00000000b       ; Set RC7-RC0 as outputs

        call    Tiny_Delay              ; Wait 100 uS

        mov     portb,#11100000b        ; Turn on steady burn arrow & both
                                        ;   load caps

        call    Tiny_Delay              ; Wait 100 uS

        mov     portb,#11110000b        ; Turn on inverter, arrow & load caps
                                        ;   all ready on

        mov     !option,#05h            ; Set Timer 0 prescaler to 64,
                                        ;    one tick = 64 uS
        mov     tmr0,#tenmsec           ; Load Timer 0 with timeout value

        clr     currentstate            ; Set these registers to zero
        clr     tenms                   ;
        clr     keyflags                ;
        clr     fiftymscnt              ;

        mov     passcntr,#passon        ; Set up pass counter for # of
passes
                                        ;       "ON"

        mov     speedptr,#7             ; Start at 300mS/State, offset =
7

        mov     inrega,porta            ; Read Port A
        snb     speedkey                ; Is SPEED key asserted?

        ret                             ; Nope, That's all folks.

        jnb     modekey,SelfTest        ; Goto SelfTest if MODE & SPEED
are
                                        ;   asserted
        ret

;****************************************************************
;
; Check timer register to see iff timed out (TMR0 = 0).  Remain in
this
; loop until the timer is timed out.

Timer_Check
        mov     w,speedptr              ; get desired offset into
Speed_table
        call    Speed_Table             ; load corresponding value into W
        mov     tenms,w                 ; Set counter for tens of
milliseconds

Tenms_Loop
        cjne    tmr0,#0,Tenms_Loop      ; Loop until Timer 0 = 0
```

```
        clr     wdt                     ; Kick the dog!
        mov     tmr0,#tenmsec           ; 10 mS elapsed, Reload timer and
                                        ;     start again

        inc     fiftymscnt
        csb     fiftymscnt,#5
        call    Check_Key               ; Check keys every 50 mS
        snb     restart
        ret
                                        ; Exit immediately to perform a re-start

        decsz   tenms                   ; Test if timed out
        jmp     Tenms_Loop              ;   Nope.

        ret                             ; Yep, All Done!

;***************************************************************
;
; Check for user input and modify operation accordingly
;
; Per Lipsky's definition,
;                       RA3 = INSERT_COIN, active high input
;                       RA2 = MODE, active low input    (KEY A)
;                       RA1 = SPEED, active low input   (KEY B)

Check_Key
        clr     fiftymscnt              ; Setup for next pass into this routine
        mov     inrega,porta            ; read & save a copy of port A
        jnb     icmodejmpr,Test4Low
        jb      insertkey,StopNWait
        ret

Test4Low
        jnb     insertkey,StopNWait
        ret

StopNWait
        setb    restart                 ; set flag to indicate that
                                        ;     we must restart upon exit

        snb     inv_enable              ; If inverter is all ready off, skip next
instruction
        mov     portb,#01110000b        ; Perform a soft turn off of the inverter
                                        ; Both load caps on, arrow off

        mov     dowhat,#23              ; wait 100 uS, settling time
Loop100us                               ; "     "       "       "
        nop                             ; "     "       "       "
        nop                             ; "     "       "       "
        decsz   dowhat                  ; "     "       "       "
        jmp     Loop100us               ; "     "       "       "

        and     portb,#01100000b        ; Inverter off now

OverNOver
        clr     dowhat                  ; wait 50 mS
Loop50ms                                ; "     "   "
        mov     tmr0,#tenmsec           ; "     "   " Load Timer 0 with 10
mS timeout value
        cjne    tmr0,#0,$               ; "     "   " Sit here and wait 10
mS
        clr     wdt                     ; Kick the dog!
        inc     dowhat                  ; "     "   "
        cjb     dowhat,#5,Loop50ms      ; "     "   "

        mov     inrega,porta            ; Read keys/inputs
        jnb     icmodejmpr,Ck4Low

        jb      insertkey,OverNOver     ; icmode jmpr = 1, so loop as
long as insertkey = 1
        ret                             ; insertkey just negated--start
afresh

Ck4Low
        jnb     insertkey,OverNOver     ; icmode jmpr = 0, so loop as
long as insertkey = 0
        ret                             ; insertkey just asserted--start
afresh

;***************************************************************
;
; This routine produces a fixed delay with an approximate length of
; 100 microseconds
;
; Actual loop execution time =  2 + (4 * (23+1)) + 3 = 101 uS
;         (1 uS/mach cycle)
;
```

```
Tiny_Delay
        mov     temp,#23            ; 2-  load with 23 as this is zero-based

Tiny_Loop
        nop                         ; 1-
        nop                         ; 1-
        decsz   temp                ; 1- if looping, 2- on exit
        jmp     Tiny_Loop           ; 1-
        ret                         ; 2-
;*****************************************************************
;
; Self Test state table
;
ST_Table
        jmp     pc+w                ;
        retw    00000001b           ; State 1  - RC0 "THIS"  & .022 ON
        retw    00000010b           ; State 2  - RC1 "$1"    "  "  "
        retw    00000100b           ; State 3  - RC2 "$5"    "  "  "
        retw    00001000b           ; State 4  - RC3 "$10"   "  "  "
        retw    00010000b           ; State 5  - RC4 "$20"   "  "  "
        retw    00100000b           ; State 6  - RC5 "$50"   "  "  "
        retw    01000000b           ; State 7  - RC6 "$100"  "  "  "
        retw    10000000b           ; State 8  - RC7 "BILLS" "  "  "
        retw    11010000b           ; State 9  - RB7 "ARROW" "  "  "
        retw    00010000b           ; State 10 - RB4
        retw    00110000b           ; State 11 - RB5
        retw    01010000b           ; State 12 - RB6

;*****************************************************************
;

Speed_Table
        jmp     pc+w                ;
        retw    2                   ; offset  0 =   20 mS
        retw    3                       ; offset  1 =   30 mS
        retw    4                 ; offset  2 =   40 mS
        retw    6                 ; offset  3 =   60 mS
        retw    9                 ; offset  4 =   90 mS
        retw    15                ; offset  5 =  150 mS
        retw    20                ; offset  6 =  200 mS
        retw    30                ; offset  7 =  300 mS
        retw    45                ; offset  8 =  450 mS
        retw    60                ; offset  9 =  600 mS
        retw    90                                  ; offset 10 =  900 mS

;*****************************************************************
;

PortC_Table
        jmp     pc+w                ;
        retw    00000001b           ; offset  0
        retw    00000010b           ; offset  1
        retw    00000100b           ; offset  2
        retw    00001000b           ; offset  3
        retw    00010000b           ; offset  4
        retw    00100000b           ; offset  5
        retw    01000000b           ; offset  6
        retw    10000000b           ; offset  7
        retw    00000000b           ; offset  8

;               --------
;               ||||||||---------- RC0 => "THIS MACHINE ACCEPTS"
;               |||||||----------- RC1 => "$1"
;               ||||||------------ RC2 => "$5"
;               |||||------------- RC3 => "$10"
;               ||||-------------- RC4 => "$20"
;               |||--------------- RC5 => "$50"
;               ||---------------- RC6 => "$100"
;               |----------------- RC7 => "BILLS"
;*****************************************************************
;

PortB_Table
        jmp     pc+w                ;
        retw    01010000b           ; offset  0
        retw    01110000b           ; offset  1
        retw    01110000b           ; offset  2
        retw    01110000b           ; offset  3
        retw    01110000b           ; offset  4
        retw    01110000b           ; offset  5
        retw    01110000b           ; offset  6
```

```
        retw    01110000b               ; offset  7
        retw    11111000b               ; offset  8

;               ^^^^^^^^
;               ||||||||---------- RB0 =>
;               |||||||----------- RB1 =>
;               ||||||------------ RB2 =>
;               |||||------------- RB3 =>
;               ||||-------------- RB4 => Enable inverter, active high
;               |||--------------- RB5 => .01 uF Load Capacitor
;               ||---------------- RB6 => .022 uF Load capacitor
;               |----------------- RB7 => "ARROW" (Steady Burn)

;*************************************************************
;
; Main Code

Start
        call    Initialize

Repeat
        cja     passcntr,#passon,Soft_Off
        mov     w,currentstate          ; get current state into W
        call    PortB_Table             ; get corresponding value from table
        mov     portb,w                 ; send it out to port B

        call    Tiny_Delay
Helga
        mov     w,currentstate          ; get current state into W
        call    PortC_Table             ; get corresponding value from table
        mov     portc,w                 ; send it out to port C

        call    Timer_Check             ; Wait a spell
        jb      restart,StartFresh      ; Start afresh iff INSERT COIN I/P
                                        ;     just negated

        inc     currentstate            ; advance state counter
        cje     currentstate,#9,ResetState

        jmp     Repeat

ResetState                              ; Reset state counter to zero
        clr     currentstate
        inc     passcntr
        cja     passcntr,#totpass,ResetPassCntr
        jmp     Repeat

StartFresh
        clr     currentstate            ; reset state machine
        clrb    restart                 ; negate restart flag & then
reset Pass register

ResetPassCntr
        mov     passcntr,#passon        ; time to start a new pass
        jmp     Repeat

Soft_Off
        snb     inv_enable              ; If inverter is all ready off,
skip
                                        ;     next instruction
        mov     portb,#01110000b        ; Perform a soft turn off of the
                                        ;     inverter
                                        ; Both load caps on, arrow off
        call    Tiny_Delay
        and     portb,#01100000b        ; Inverter off now

        jmp     Helga

;*************************************************************
;
; Sit & waste 50 milliseconds
;

FiftyMS
        clr     dowhat                  ;
        clr     wdt                     ; Kick the dog!
FiftyLoop
        mov     tmr0,#tenmsec           ; Load Timer 0 with 10 mS timeout
value
        cjne    tmr0,#0,$               ; Sit here and wait 10 mS
        clr     wdt                     ; Kick the dog!
        inc     dowhat
        cjb     dowhat,#5,FiftyLoop
        ret
```

```
;***************************************************************
;
; SPEED key must be asserted upon entrance. This routine reads the
;  keypad and loops until the SPEED key ("B") is released.
;

WaitForKey
        clr     wdt                     ; Kick the dog!
        mov     inrega,porta            ; Read Keys
        jnb     speedkey,WaitForKey     ; Loop until key is de-asserted
        ret

;***************************************************************
;
; currentstate = zero upon entry
; temp will be used to hold value to be outputted
; stout will hold value from ST_Table which is to be outputted on
; port B & C
;

        org     100h

SelfTest
        clr     portb                   ; set all port B & C outputs off
        clr     portc
        setb    loadcap22               ; Enable .022uf load cap

StartST
        call    WaitForKey              ; Debounce Speed Key

StateLoop0
        mov     inrega,porta            ; Read keys/inputs

        sb      insertkey               ; insertkey is asserted, so leave
        clrb    inv_enable              ; inverter on

        snb     insertkey               ; insertkey negated, so leave
        setb    inv enable              ;   inverter off

        call    FiftyMS                 ; Waste 50 mS

        jb      speedkey,StateLoop0     ; Loop as long as SpeedKey;
                                        ;   is de-asserted
        call    WaitForKey              ; Stay here until Speed key
                                        ;   is de-asserted

        setb    inv_enable              ; Enable inverter

StateLoopMain
        mov     w,currentstate          ; load offset into table
        call    ST_Table                ; get table value
        mov     stout,w
        cje     currentstate,#7,DoPortB
        mov     portc,stout             ; Output to Port C for States
1-8,
                                        ;  .022 uf load cap enabled

Waiting
        call    FiftyMS                 ; Waste 50 mS
        mov     inrega,porta            ; read keys/inputs

        jb      speedkey,StateLoopMain

NextState
        call    WaitForKey              ; we got a key, now debounce it

        inc     currentstate
        cje     currentstate,#15,StartOver
        cje     currentstate,#14,ZcrossCk
        cje     currentstate,#13,LVoltCk
        cje     currentstate,#12,AllOn

        jmp     StateLoopMain

DoPortB
        clr     portc                   ; Turn everything off on C
        mov     portb,stout             ; Output to Port B for states
9-12
        jmp     Waiting

AllOn
        mov     portc,#0FFh
        mov     portb,#0F0h
```

```
        call    FiftyMS                 ; waste 50 mS
        mov     inrega,porta            ; Read Keys/Inputs

        jb      speedkey,AllOn

        clr     portc                   ; setup ports for next state
        mov     portb,#01110000b
        jmp     NextState

LVoltCk
        or      portb,#00000100b        ; Turn on all load caps,
                                        ;     inv is enabled
                                        ;   activate external load cap by
                                        ;     asserting RB2. LVOLT input
                                        ;       to PIC
                                        ;       should be HI now!

        call    FiftyMS                 ; waste 50 mS
        mov     inrega,porta            ; Read Keys/Inputs

        jb      speedkey,LVoltCk
        and     portb,#01010000b        ; Leave .022uf ON & inverter enabled
                                        ;   all others off
        jmp     NextState

ZcrossCk
        sb      zerox                   ; if it's low, go wait for + edge
        jmp     Low2High          ;       else...

High2Low                                ; wait for - edge transition
        clr     wdt                     ; Kick the dog!
        jb      zerox,High2Low
        clrb    RB.3
        jmp     OneMoreTime

Low2High
        clr     wdt                     ; Kick the dog!
        jnb     zerox,Low2High          ; wait for + edge transition
        setb    RB.3

OneMoreTime
        mov     inrega,porta            ; Read Keys/Inputs

        jb      speedkey, ZcrossCk
        jmp     NextState

StartOver
        clr     portb
        clr     portc
        setb    loadcap22               ; turn on .022 uF load
        clr     currentstate
        clr     wdt                     ; Kick the dog!
        jmp     StateLoop0

;******************************************************************
;
        retw    'Copyright 1996, Add-Vision Inc. by Mark W. Bevington'

;******************************************************************
;
; Reset Vector

        org     pic55
System_Reset
        jmp     Start

        end
```

What is claimed is:

1. An apparatus for controlling a plurality of electroluminescent display elements to create animated displays, the apparatus comprising:

a microcontroller;

a power supplying circuit for supplying a driving signal, the driving signal being of an appropriate magnitude and frequency to drive the electroluminescent display elements; and

a selection circuit connected to receive a plurality of signals from the microcontroller and to receive the driving signal from the power supplying circuit, the selection circuit selectively forwarding the driving signal to each of the individual electroluminescent display elements based on the signals received from the microcontroller,

wherein the microcontroller turns each of said display elements on or off in a sequence, thereby generating animated displays.

2. The controlling apparatus of claim 1, wherein the magnitude and frequency of the driving signal emanating from the power supply circuit can be varied to thereby alter the color and intensity of light emanated by the electroluminescent display elements.

3. The controlling apparatus of claim 2, wherein the magnitude and frequency of the driving signal is dynamically controlled by the microcontroller.

4. The controlling apparatus of claim 1, wherein for each of said electroluminescent dismay elements, the panel selection circuit selects whether to forward the driving signal based on a circuit comprising:

a resistor connected to the microcontroller at one end;

a transistor having a base, emitter, and collector, the transistor being connected to the other end of the resistor at the transistor base and the transistor being connected to the power supplying circuit at the collector end, the transistor being in the on state when the microcontroller allows current to

flow through the resistor; and

A diode bridge connected to the collector of the transistor and to said each of the electroluminescent panels.

5. The controlling apparatus of claim 1, wherein the microcontroller is connected to a push button switch allowing the user to input functions to be performed by the microcontroller.

6. The controlling apparatus of claim 1, wherein the power supplying circuit further comprises:

a function generator for generating periodic signal;

a power amplifier, connected to the function generator, for amplifying the periodic signals; and

a transformer connected to the power amplifier.

7. The controlling apparatus of claim 1, wherein the electroluminescent display elements are electroluminescent filaments.

8. The controlling apparatus of claim 1, wherein the electroluminescent display elements are electroluminescent panels.

9. An apparatus for controlling an electroluminescent panel to create animate displays, the apparatus comprising:

a power supply for supplying high voltage power;

a microcontroller for supplying a timing signal, a data signal, and a polarity signal; and

a driver circuit operating synchronously with the timing signal and receiving the data signal and the polarity signal from the microcontroller, the driver circuit causing the electroluminescent panel to illuminate if the data signal is high and the polarity signal is high by charging said electroluminescent panel from said power supply and the driver circuit causing the electroluminescent panel to illuminate if the data signal is high and the polarity signal is low by discharging said electroluminescent panel;

wherein the microcontroller controls the color of the electroluminescent panel by varying the frequency of the timing signal.

10. The controlling apparatus of claim 9, further comprising a second EL panel and a multiplexor circuit, wherein based on the timing signal the multiplexor alternatively selects one of the electroluminescent panel and the second electroluminescent panel whereby an expected illumination life of the electroluminescent Dane! and the second electroluminescent panel is increased.

11. The controlling apparatus of claim 9, wherein the microcontroller controls the color by varying the duty cycle of the timing signal.

12. An apparatus for controlling electroluminescent panels to create animated displays, the apparatus comprising:

a power supply supplying high voltage DC power;

a voltage ground;

a microcontroller supplying signal lines for controlling on and off state of the panels; and

solid state switching logic coupled to the power supply and the panels, receiving the signal lines from the microcontroller, and for alternatively charging the panels from the power supply and discharging the panels to the voltage ground based on the signal lines, wherein the panels emit light during the charging and discharging operations.

13. A retrofit electroluminescent (EL) lighting system, for use with a host machine, to produce lighting effects in response to lamp power signals that are provided from the host system and that would otherwise be used to power lamps of the host machine, the retrofit lighting system comprising:

an EL lamp system having a plurality of EL lamp cells;

sequencing circuitry providing an EL lamp driving signal to independently control each of the EL lamp cells of the EL lamp system such that the EL lamp cells collectively illuminate in a sequence corresponding to the EL lamp driving signal; and

signal conditioning circuitry that non-invasively samples the lamp

power signals provided from the host system and that provides the EL lamp driving signal in response thereto.

14. A retrofit electroluminescent (EL) lighting system, for use with a host machine, to produce lighting effects in response to lamp power signals that are provided from the host system and that would otherwise be used to power lamps of the host machine, the retrofit lighting system comprising:

an EL lamp system having a plurality of EL lamp cells;

sequencing circuitry providing an EL lamp driving signal to independently control each of the EL lamp cells of the EL lamp system such that the EL lamp cells collectively illuminate in a sequence corresponding to the EL lamp driving signal; and

signal conditioning circuitry that samples the lamp power signals provided from the host system and that provides the EL lamp driving signal in response thereto.

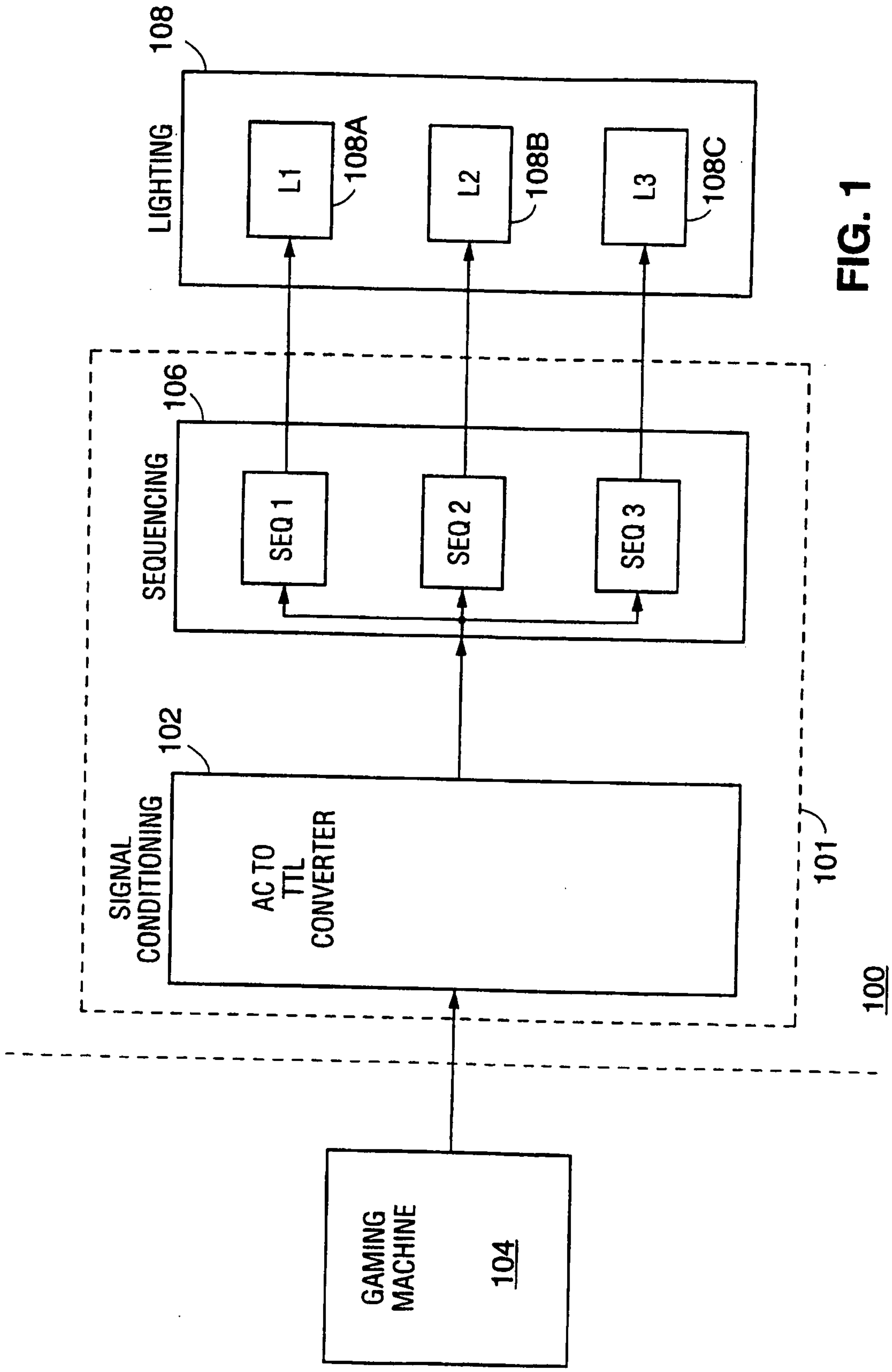
LIGHTING
108
L1
108A
L2
108B
L3
108C
SEQUENCING
106
SEQ 1
SEQ 2
SEQ 3
SIGNAL CONDITIONING
102
AC TO TTL CONVERTER
101
100
GAMING MACHINE
104

FIG. 1

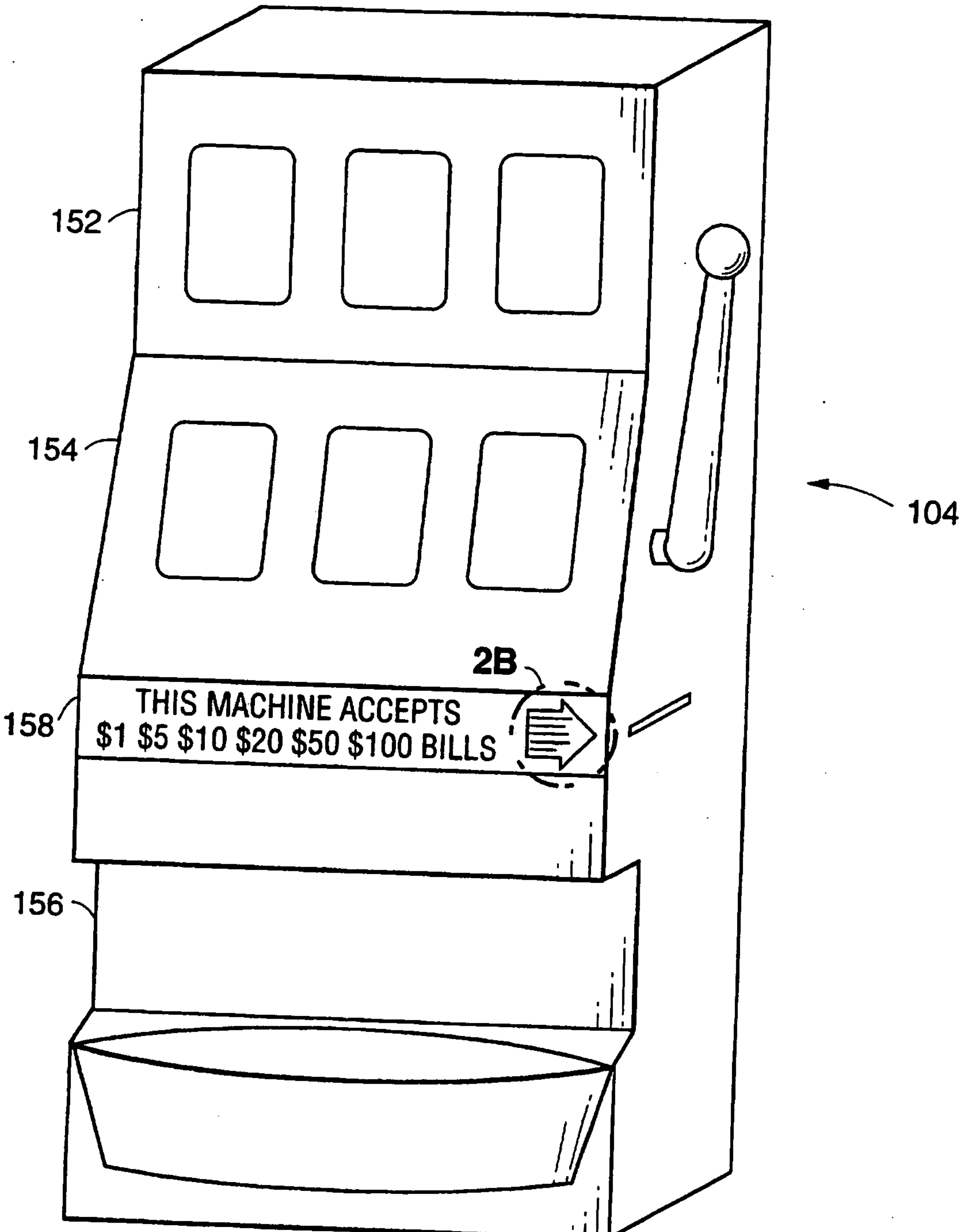
152
154
104
2B
158
THIS MACHINE ACCEPTS
$1 $5 $10 $20 $50 $100 BILLS
156

FIG. 2A

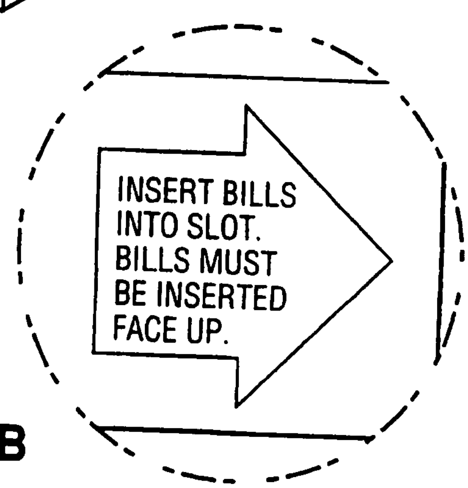
INSERT BILLS
INTO SLOT.
BILLS MUST
BE INSERTED
FACE UP.

FIG. 2B

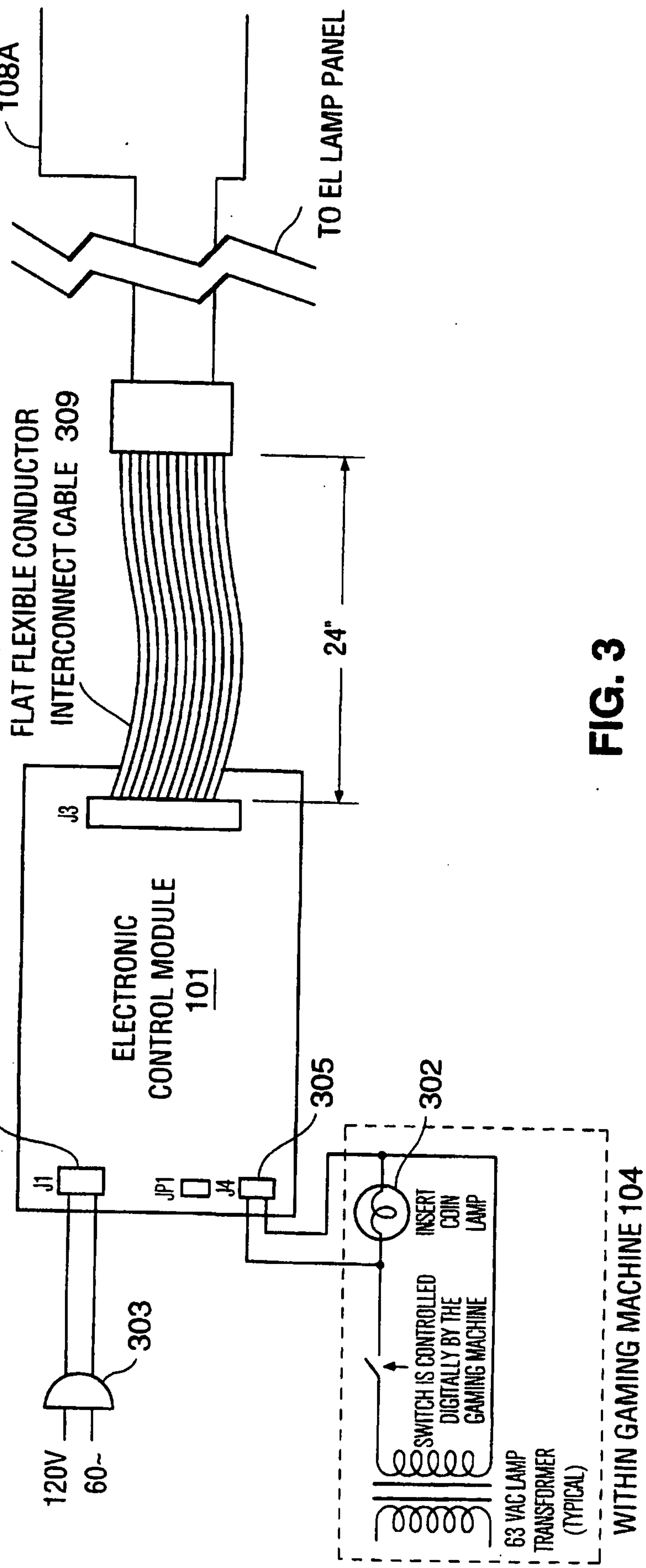
108A
TO EL LAMP PANEL
FLAT FLEXIBLE CONDUCTOR
INTERCONNECT CABLE 309
24"
J3
ELECTRONIC
CONTROL MODULE
101
301
J1
JP1
J4
305
302
INSERT
COIN
LAMP
SWITCH IS CONTROLLED
DIGITALLY BY THE
GAMING MACHINE
303
120V
60~
63 VAC LAMP
TRANSFORMER
(TYPICAL)
WITHIN GAMING MACHINE 104

FIG. 3

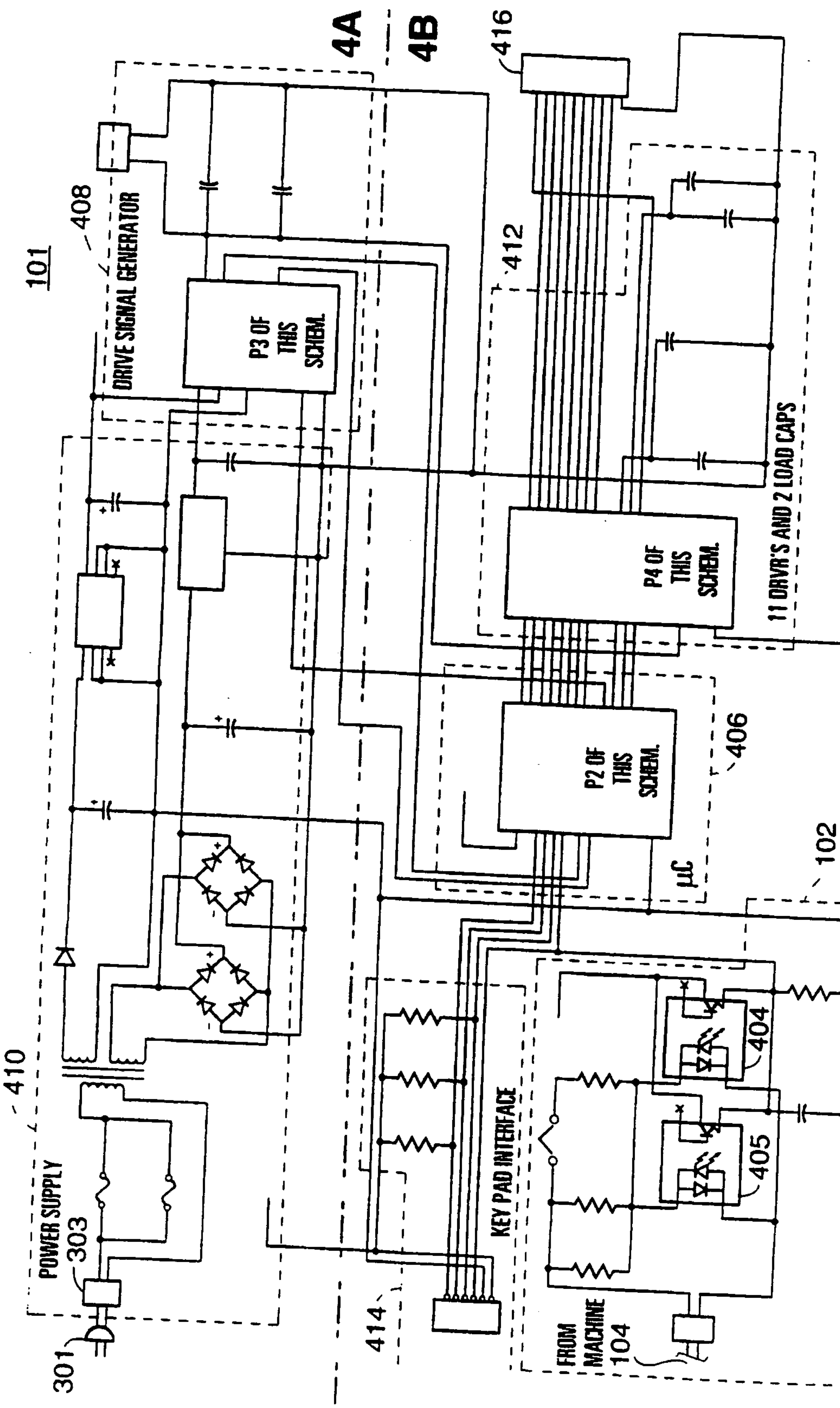
101
408
DRIVE SIGNAL GENERATOR
P3 OF THIS SCHEM.
4A
4B
416
412
11 DRVR'S AND 2 LOAD CAPS
P4 OF THIS SCHEM.
P2 OF THIS SCHEM.
406
μC
102
404
405
HOST MACHINE INTERFACE
FROM MACHINE
104
KEY PAD INTERFACE
414
410
POWER SUPPLY
303
301

FIG. 4 (MAP)

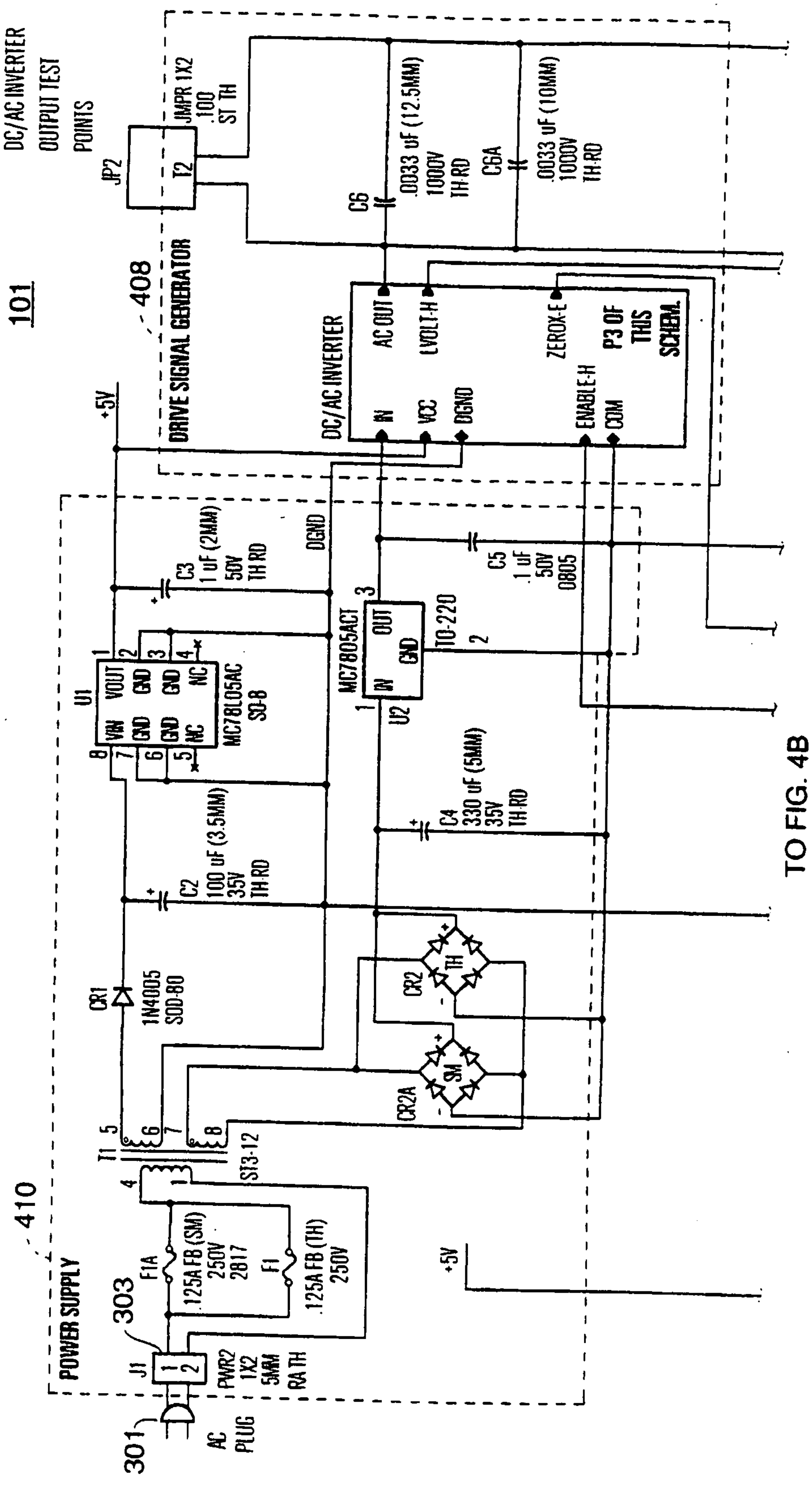
101
DC/AC INVERTER OUTPUT TEST POINTS
JP2
T2
JMPR 1X2 .100 ST TH
408
DRIVE SIGNAL GENERATOR
C6
.0033 uF (12.5MM) 1000V TH-RD
C6A
.0033 uF (10MM) 1000V TH-RD
DC/AC INVERTER
AC OUT
LVOLT-H
ZEROX-E
P3 OF THIS SCHEM.
IN
VCC
DGND
ENABLE-H
COM
+5V
C3 1 uF (2MM) 50V TH RD
DGND
C5 .1 uF 50V 0805
U1
VOUT
GND
NC
VIN
MC78L05AC SO-8
MC7805ACT
OUT
GND
IN
U2
TO-220
C4 330 uF (5MM) 35V TH-RD
C2 100 uF (3.5MM) 35V TH-RD
CR1 1N4005 SOD-80
CR2
TH
CR2A
SM
T1
ST3-12
410
POWER SUPPLY
303
F1A .125A FB (SM) 250V 2817
F1 .125A FB (TH) 250V
+5V
J1
PWR2 1X2 5MM RA TH
301
AC PLUG
TO FIG. 4B

FIG. 4A

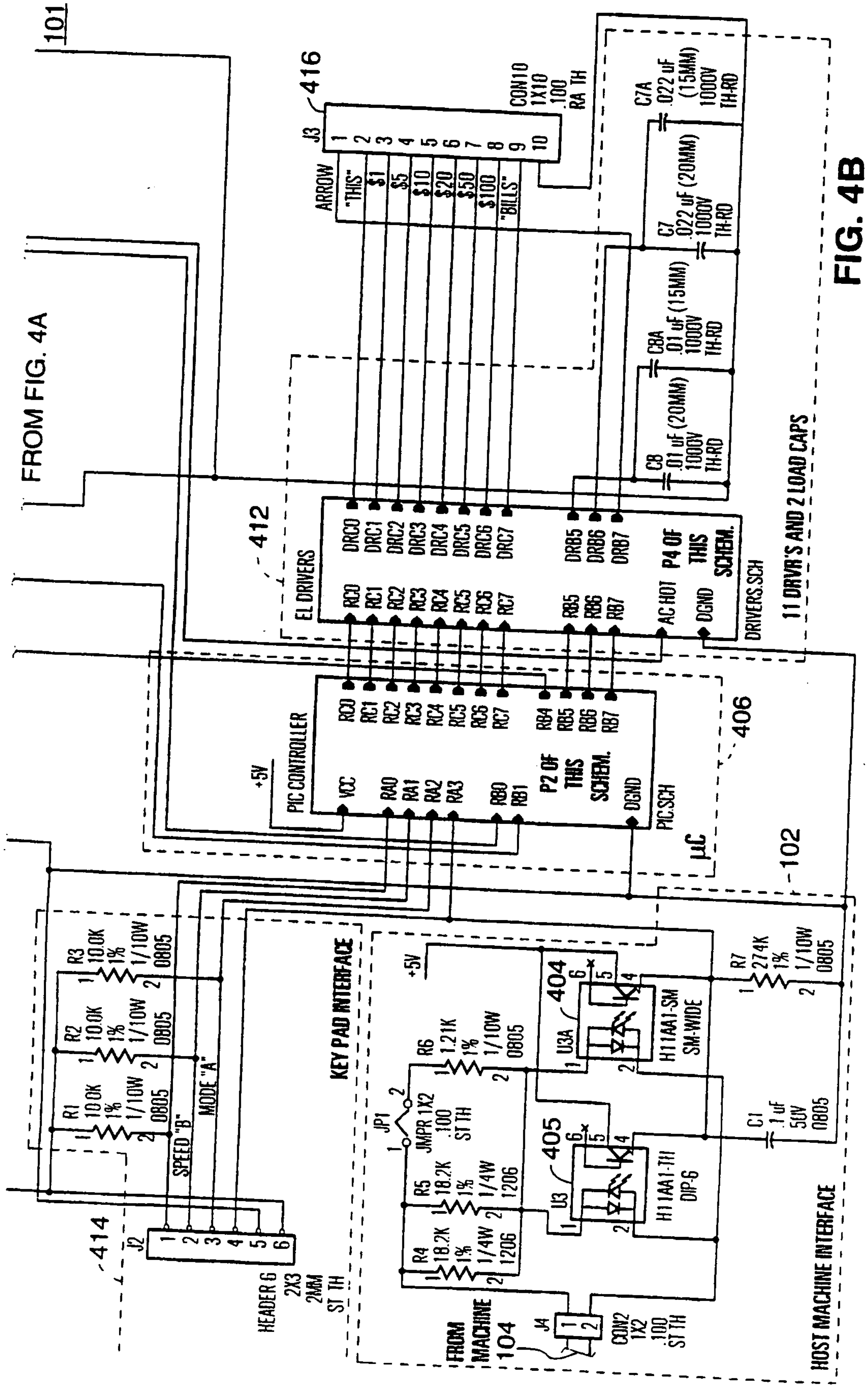
101
FROM FIG. 4A
416
J3
CON10
1X10
.100
RA TH
ARROW
"THIS"
$1
$5
$10
$20
$50
$100
"BILLS"
C7A
.022 uF (15MM)
1000V
TH-RD
C7
.022 uF (20MM)
1000V
TH-RD
C8A
.01 uF (15MM)
1000V
TH-RD
C8
.01 uF (20MM)
1000V
TH-RD
412
EL DRIVERS
P4 OF THIS SCHEM.
DRIVERS.SCH
11 DRVR'S AND 2 LOAD CAPS
AC HOT
DGND
406
PIC CONTROLLER
+5V
P2 OF THIS SCHEM.
PIC.SCH
µC
102
R1
R2
R3
10.0K
1%
1/10W
0805
SPEED "B"
MODE "A"
KEY PAD INTERFACE
414
J2
HEADER 6
2X3
2MM
ST TH
404
U3A
H11AA1-SM
SM-WIDE
405
U3
H11AA1-TH
DIP-6
R7
274K
R6
1.21K
R5
18.2K
R4
18.2K
JP1
JMPR 1X2
C1
.1 uF
50V
J4
CON2
1X2
FROM MACHINE
104
HOST MACHINE INTERFACE

FIG. 4B

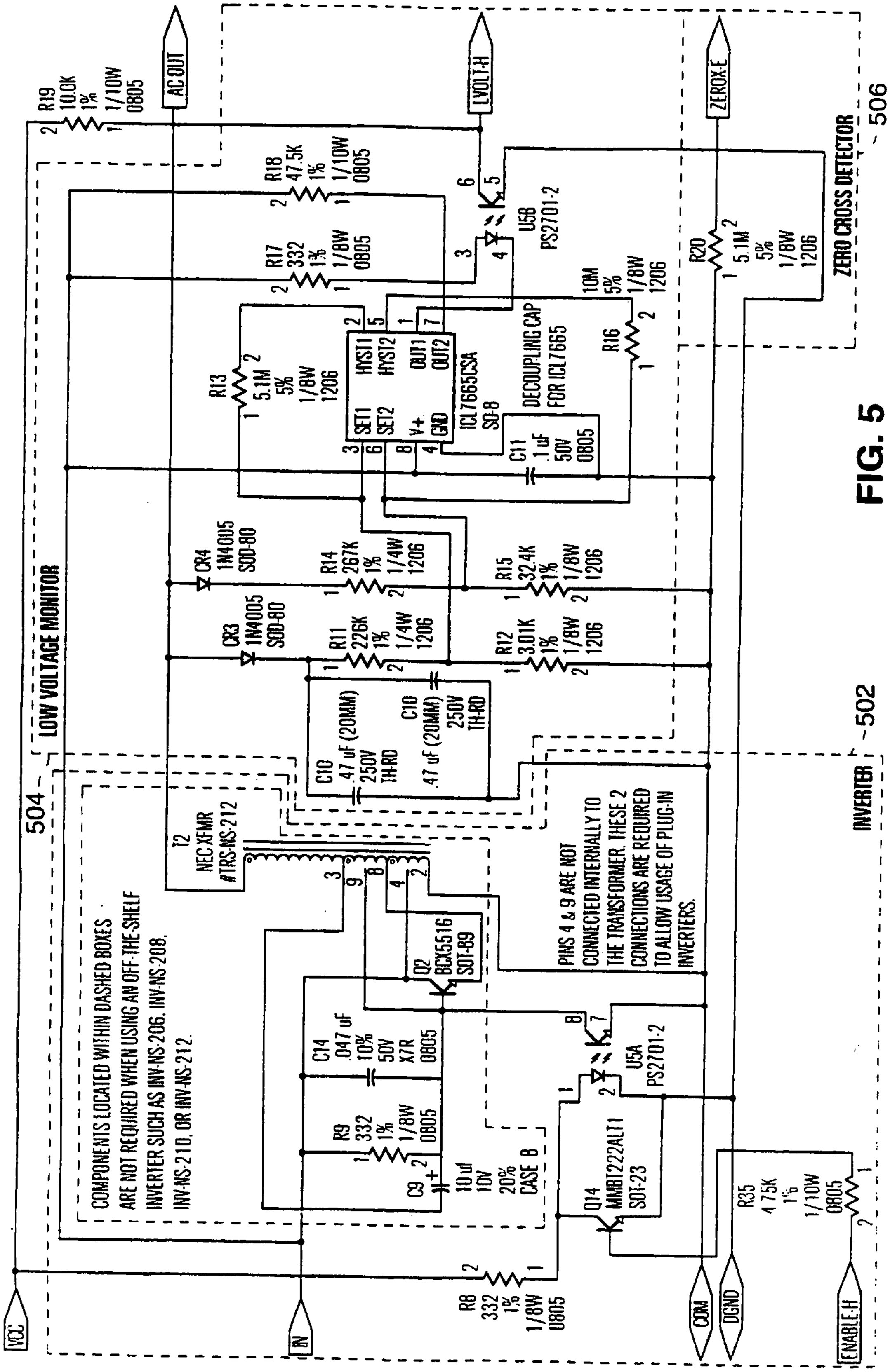
AC OUT
LVOLT-H
ZEROX-E
R19 10.0K 1% 1/10W 0805
R18 47.5K 1% 1/10W 0805
R17 332 1% 1/8W 0805
U5B PS2701-2
R20 5.1M 5% 1/8W 1206
ZERO CROSS DETECTOR
506
R13 5.1M 5% 1/8W 1206
SET1 SET2 V+ GND HYST1 HYST2 OUT1 OUT2
ICL7665CSA SO-8
DECOUPLING CAP FOR ICL7665
C11 .1 uF 50V 0805
R16 10M 5% 1/8W 1206
CR4 1N4005 SOD-80
CR3 1N4005 SOD-80
R14 267K 1% 1/4W 1206
R15 32.4K 1% 1/8W 1206
R11 226K 1% 1/4W 1206
R12 3.01K 1% 1/8W 1206
C10 .47 uF (20MM) 250V TH-RD
LOW VOLTAGE MONITOR
504
502
T2 NEC XFMR #TRS-NS-212
Q2 BCX5516 SOT-89
PINS 4 & 9 ARE NOT CONNECTED INTERNALLY TO THE TRANSFORMER. THESE 2 CONNECTIONS ARE REQUIRED TO ALLOW USAGE OF PLUG-IN INVERTERS.
INVERTER
COMPONENTS LOCATED WITHIN DASHED BOXES ARE NOT REQUIRED WHEN USING AN OFF-THE-SHELF INVERTER SUCH AS INV-NS-206, INV-NS-208, INV-NS-210, OR INV-NS-212.
C14 .047 uF 10% 50V X7R 0805
R9 332 1% 1/8W 0805
C9 10 uf 10V 20% CASE B
U5A PS2701-2
Q14 MMBT2222ALT1 SOT-23
R35 4.75K 1% 1/10W 0805
R8 332 1% 1/8W 0805
VCC
IN
COM
DGND
ENABLE-H

FIG. 5

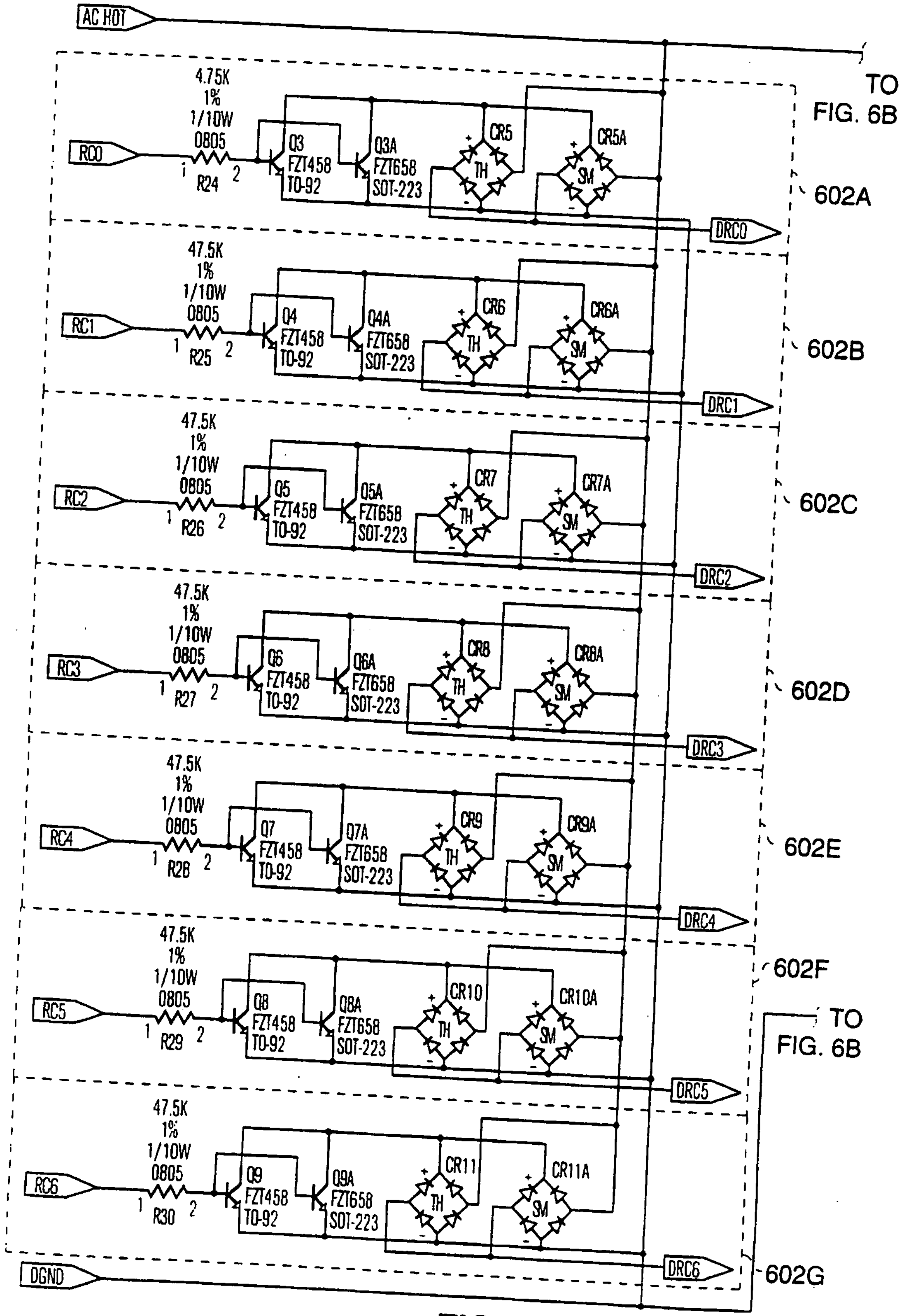
AC HOT
TO FIG. 6B
4.75K 1% 1/10W 0805
RC0
R24
Q3 FZT458 TO-92
Q3A FZT658 SOT-223
CR5
TH
CR5A
SM
DRC0
602A
47.5K 1% 1/10W 0805
RC1
R25
Q4 FZT458 TO-92
Q4A FZT658 SOT-223
CR6
CR6A
DRC1
602B
RC2
R26
Q5 FZT458 TO-92
Q5A FZT658 SOT-223
CR7
CR7A
DRC2
602C
RC3
R27
Q6 FZT458 TO-92
Q6A FZT658 SOT-223
CR8
CR8A
DRC3
602D
RC4
R28
Q7 FZT458 TO-92
Q7A FZT658 SOT-223
CR9
CR9A
DRC4
602E
RC5
R29
Q8 FZT458 TO-92
Q8A FZT658 SOT-223
CR10
CR10A
DRC5
602F
TO FIG. 6B
RC6
R30
Q9 FZT458 TO-92
Q9A FZT658 SOT-223
CR11
CR11A
DRC6
602G
DGND

FIG. 6A

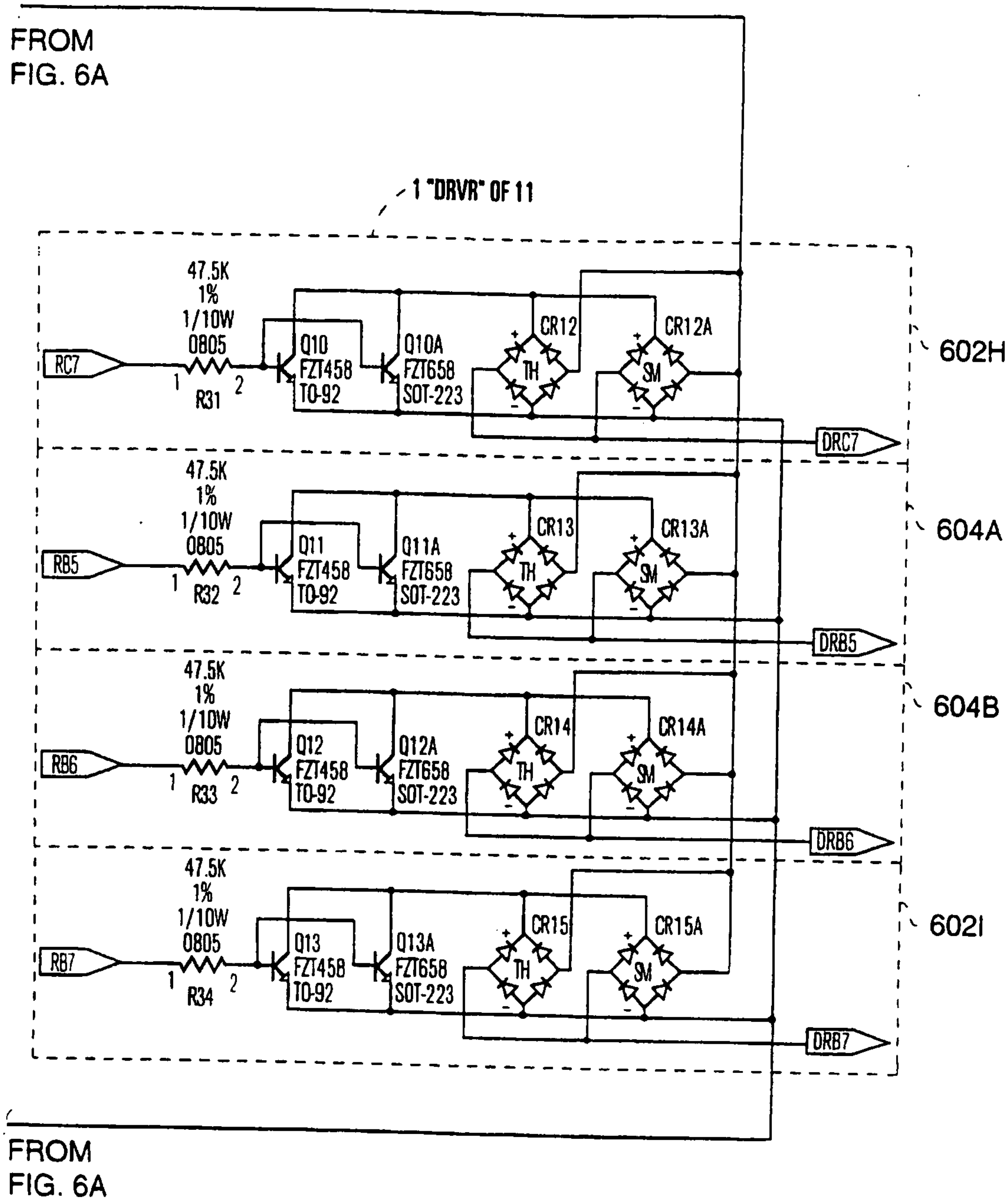
FROM
FIG. 6A
1 "DRVR" OF 11
47.5K
1%
1/10W
0805
RC7
R31
Q10
FZT458
TO-92
Q10A
FZT658
SOT-223
CR12
TH
CR12A
SM
DRC7
602H
RB5
R32
Q11
Q11A
CR13
CR13A
DRB5
604A
RB6
R33
Q12
Q12A
CR14
CR14A
DRB6
604B
RB7
R34
Q13
Q13A
CR15
CR15A
DRB7
602I
FROM
FIG. 6A

FIG. 6B

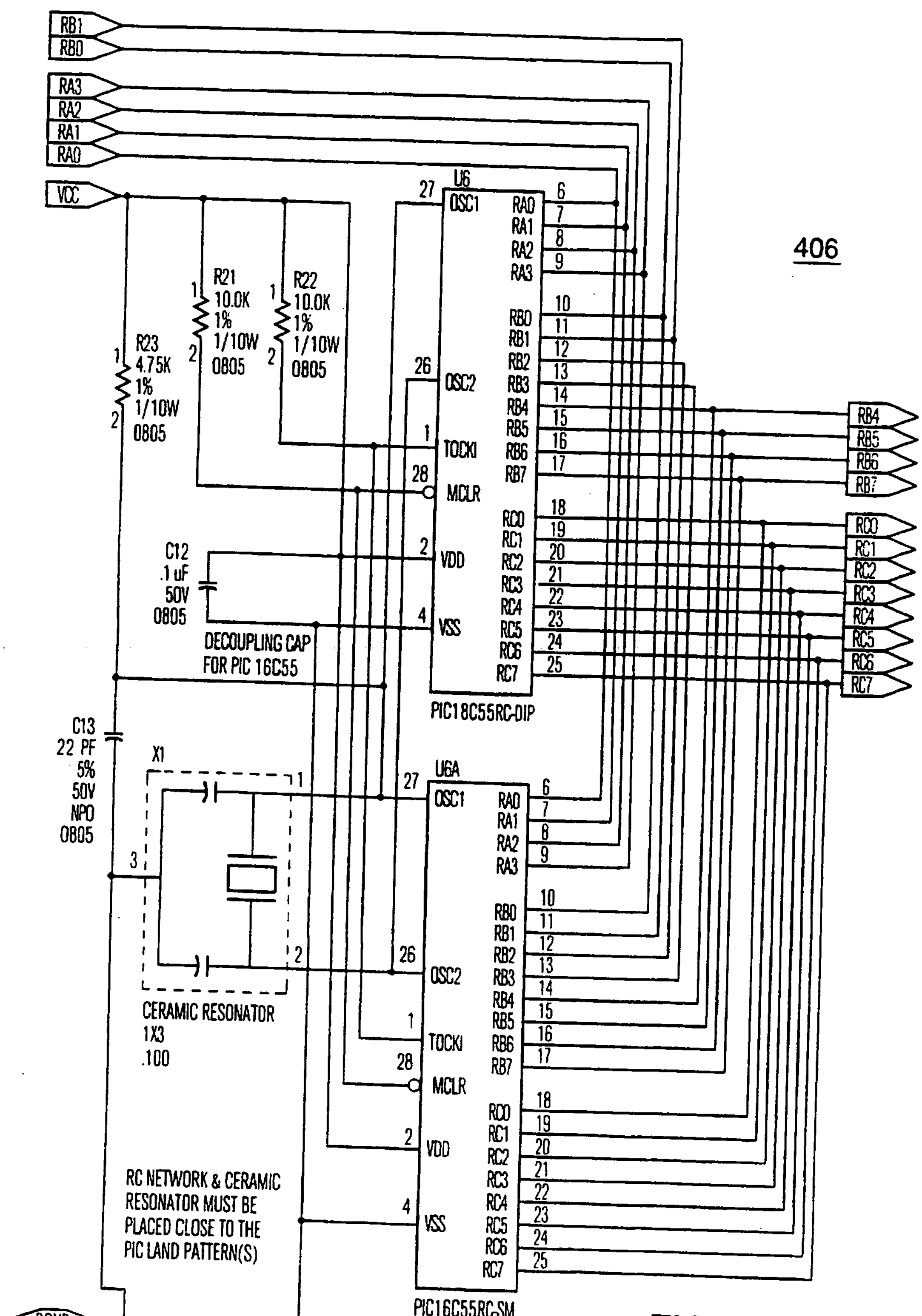
RB1
RB0
RA3
RA2
RA1
RA0
VCC
U6
406
R21
10.0K
1%
1/10W
0805
R22
10.0K
1%
1/10W
0805
R23
4.75K
1%
1/10W
0805
OSC1
OSC2
TOCKI
MCLR
VDD
VSS
C12
.1 uF
50V
0805
DECOUPLING CAP
FOR PIC 16C55
PIC18C55RC-DIP
RB4
RB5
RB6
RB7
RC0
RC1
RC2
RC3
RC4
RC5
RC6
RC7
C13
22 PF
5%
50V
NPO
0805
X1
U6A
CERAMIC RESONATOR
1X3
.100
RC NETWORK & CERAMIC
RESONATOR MUST BE
PLACED CLOSE TO THE
PIC LAND PATTERN(S)
DGND
PIC16C55RC-SM

FIG. 7

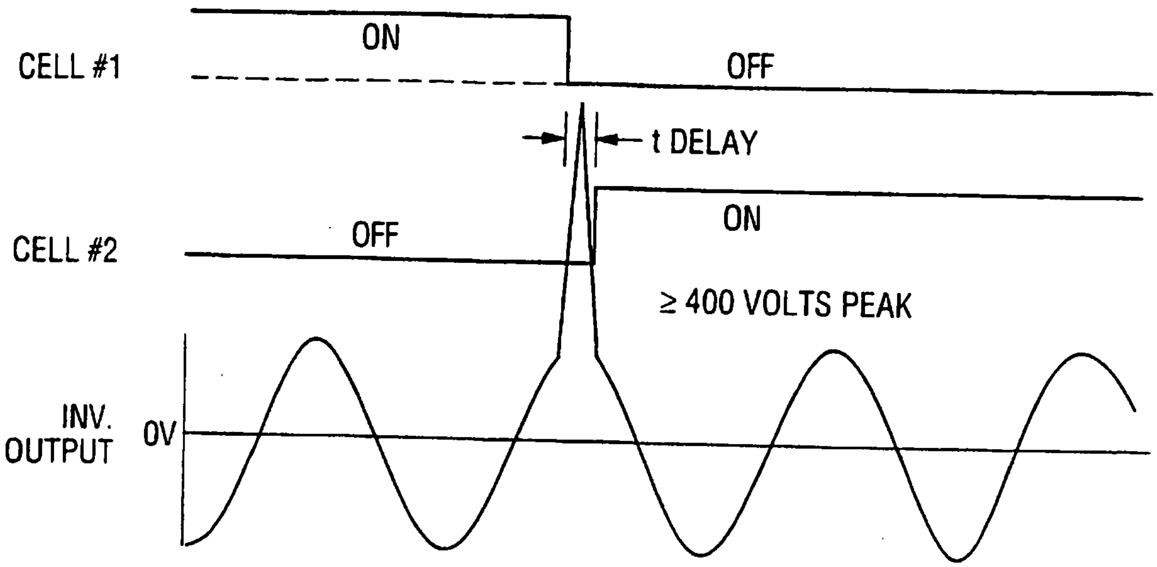
CELL #1
ON
OFF
t DELAY
CELL #2
OFF
ON
≥ 400 VOLTS PEAK
INV. OUTPUT
0V

FIG. 8

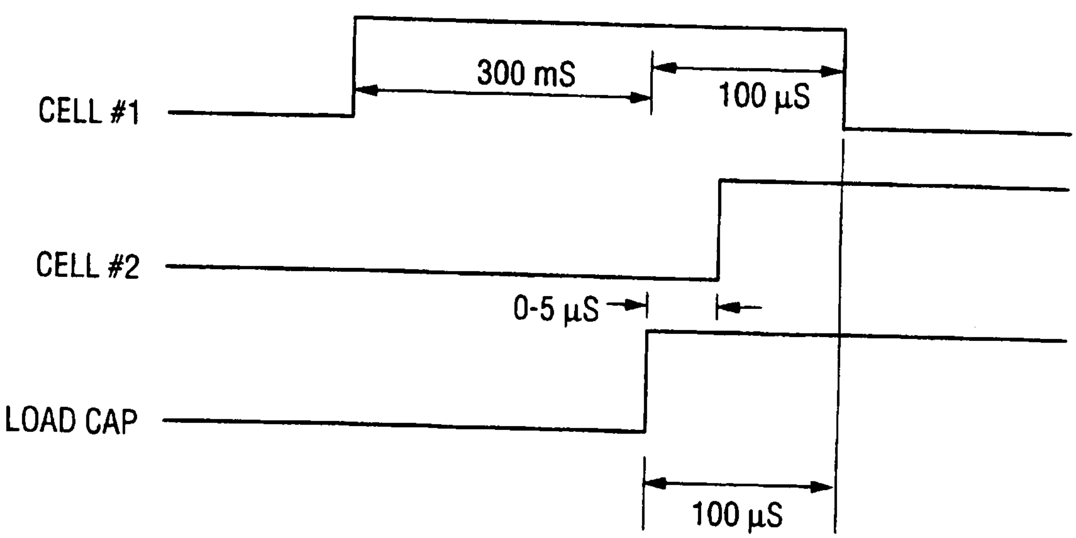
CELL #1
300 mS
100 µS
CELL #2
0-5 µS
LOAD CAP
100 µS

FIG. 9

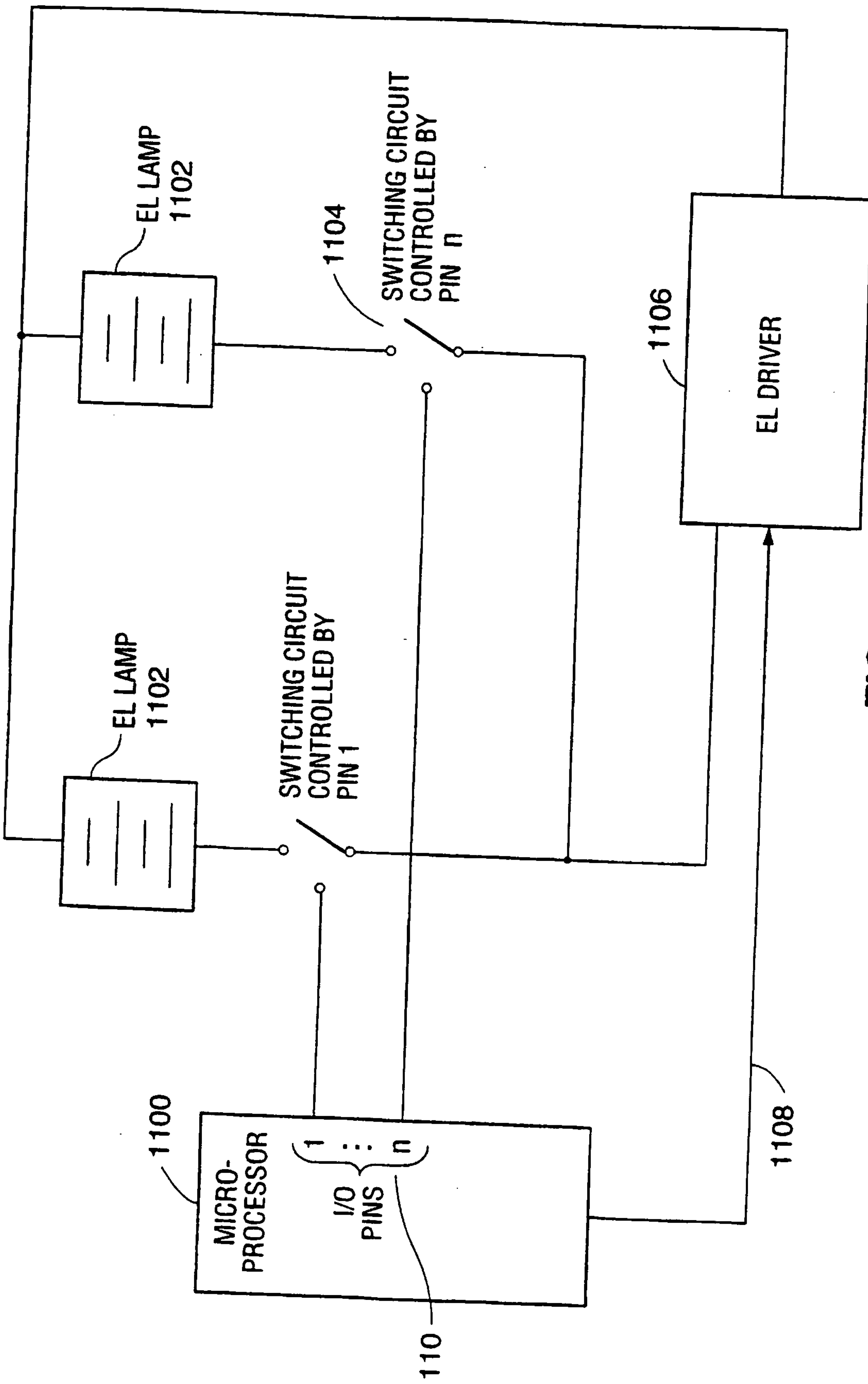
EL LAMP
1102
SWITCHING CIRCUIT
CONTROLLED BY
PIN n
1104
1106
EL DRIVER
EL LAMP
1102
SWITCHING CIRCUIT
CONTROLLED BY
PIN 1
1100
MICRO-
PROCESSOR
I/O
PINS
1
n
1110
1108

FIG. 10

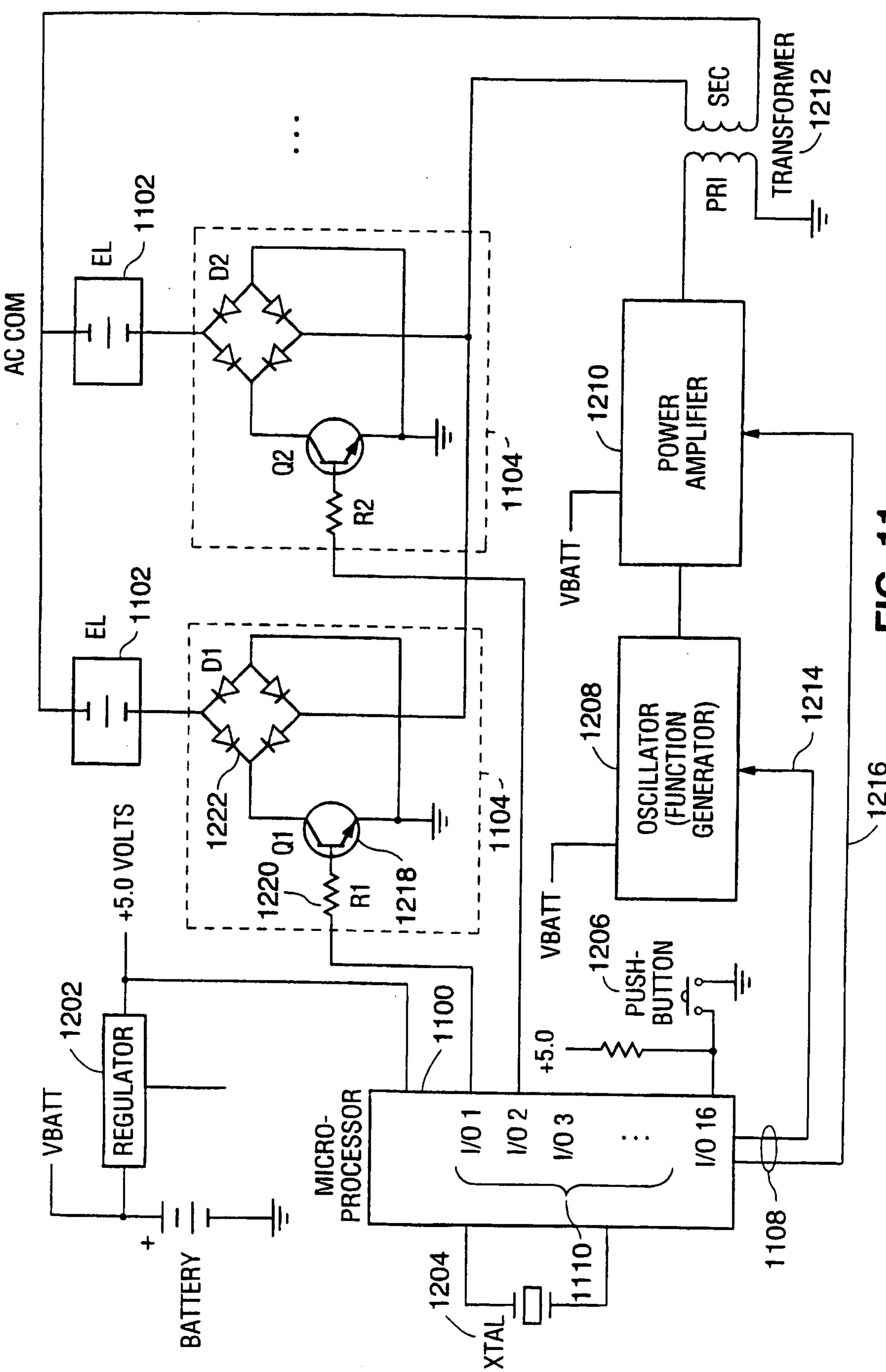
AC COM
EL
1102
D2
Q2
R2
1104
EL
1102
D1
1222
Q1
1220
R1
1218
1104
+5.0 VOLTS
VBATT
REGULATOR
1202
BATTERY
+
MICRO-
PROCESSOR
1100
I/O 1
I/O 2
I/O 3
I/O 16
1110
1204
XTAL
1108
+5.0
PUSH-
BUTTON
1206
VBATT
OSCILLATOR
(FUNCTION
GENERATOR)
1208
1214
1216
VBATT
POWER
AMPLIFIER
1210
PRI
SEC
TRANSFORMER
1212

FIG. 11

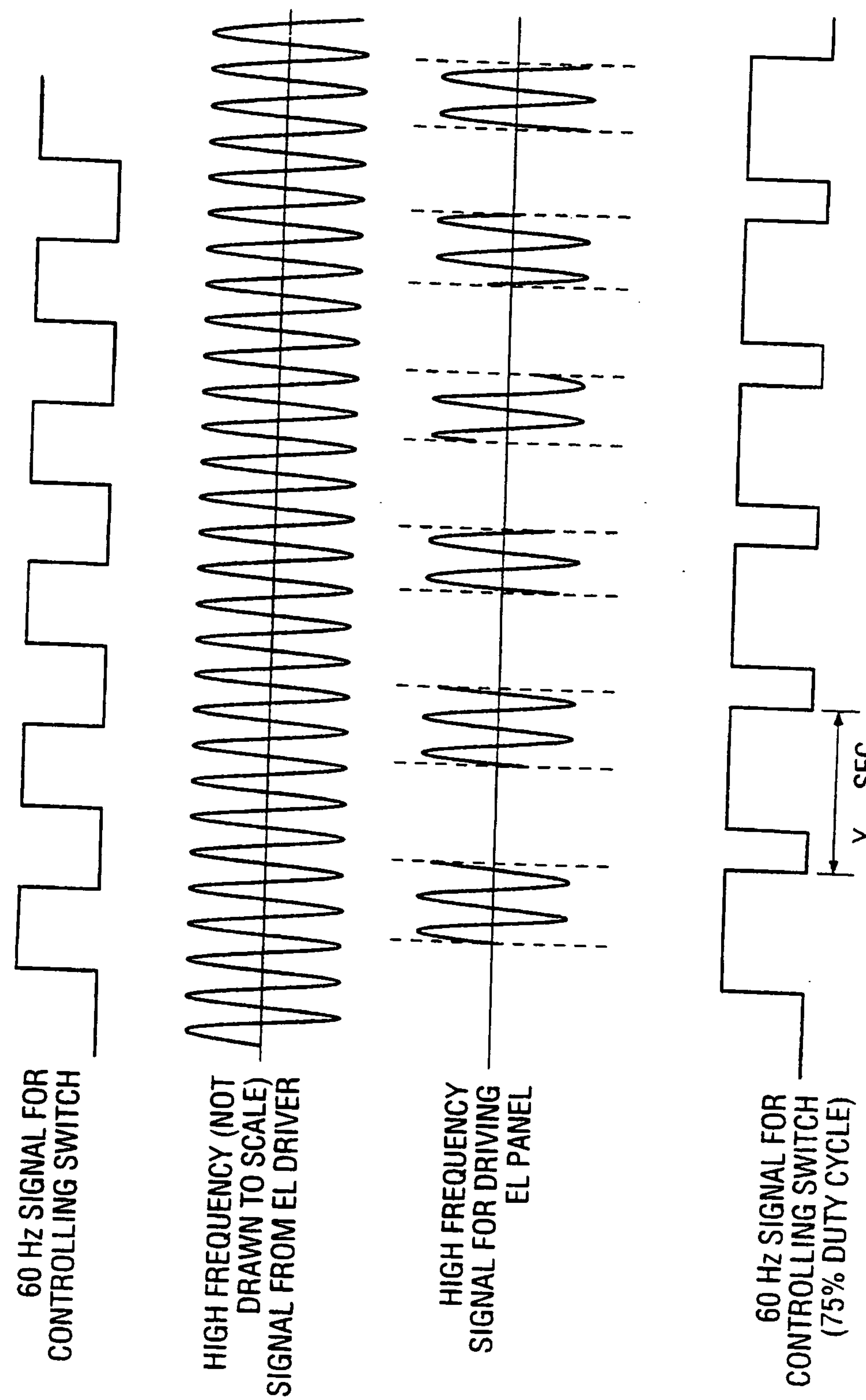

FIG. 12A

FIG. 12B

FIG. 12C

FIG. 12D

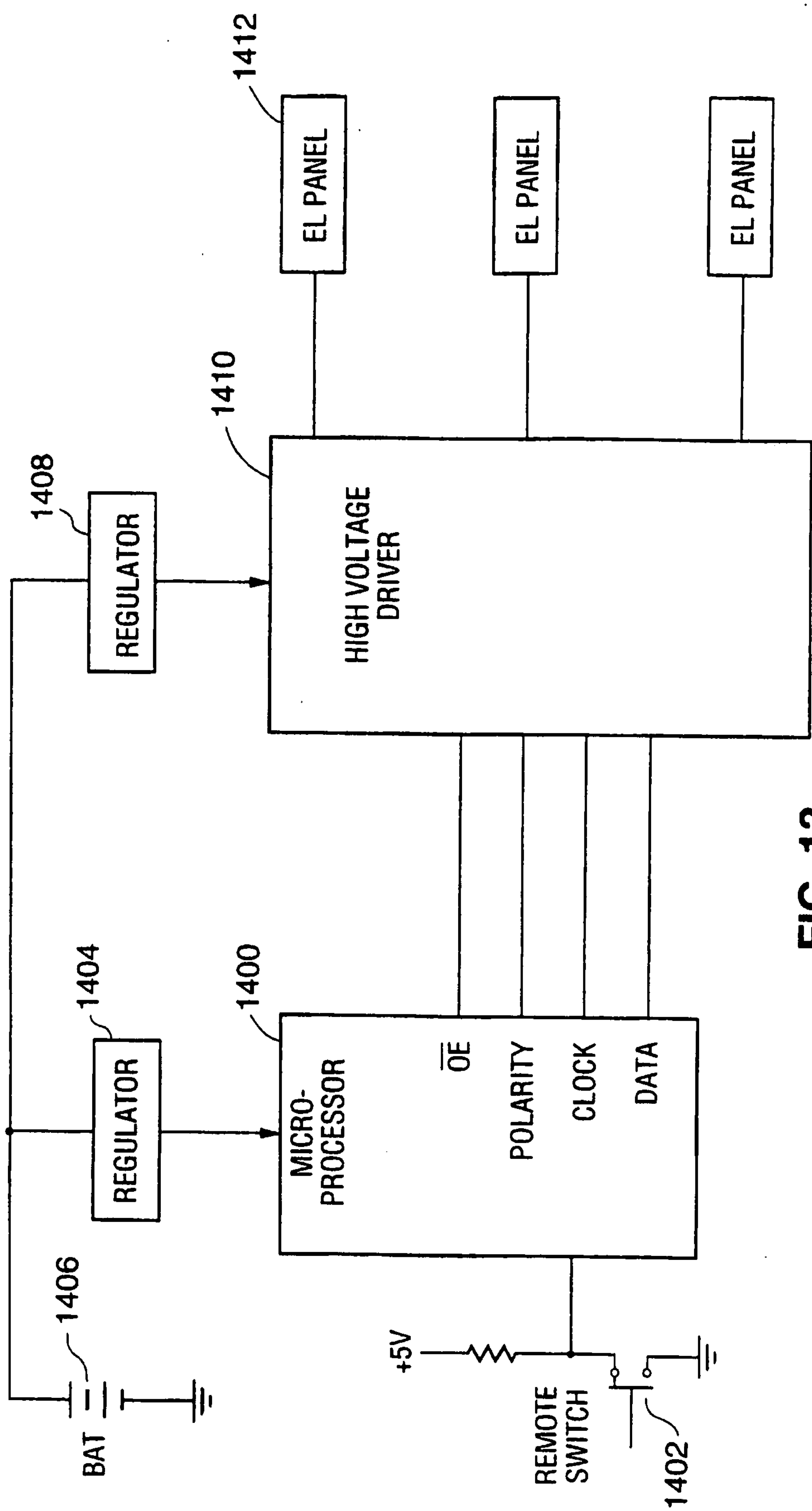
1412
EL PANEL
EL PANEL
EL PANEL
1410
HIGH VOLTAGE
DRIVER
1408
REGULATOR
1404
REGULATOR
1400
MICRO-
PROCESSOR
OE
POLARITY
CLOCK
DATA
1406
BAT
+5V
REMOTE
SWITCH
1402

FIG. 13

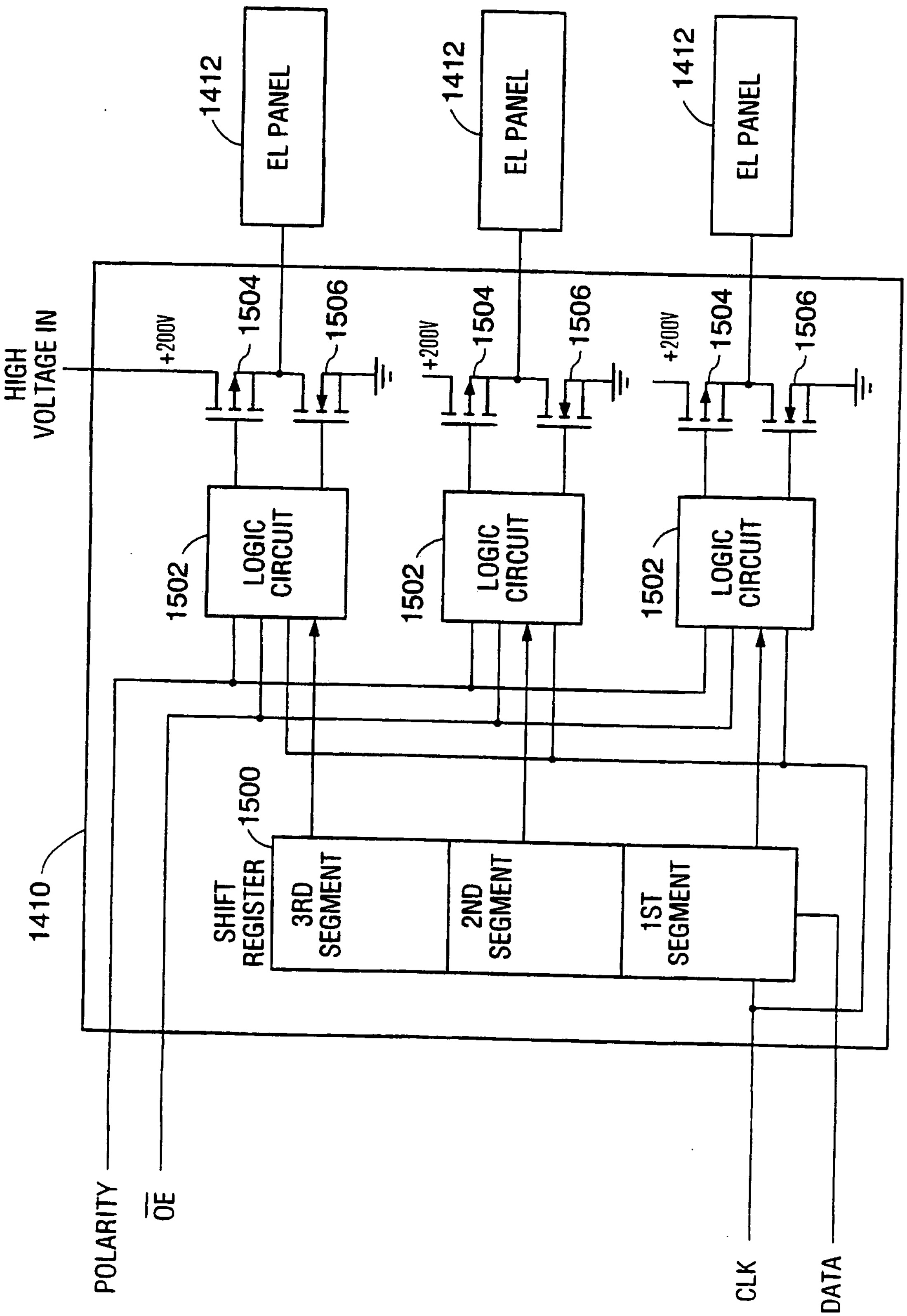
1412
EL PANEL
1412
EL PANEL
1412
EL PANEL
HIGH VOLTAGE IN
+200V
1504
1506
+200V
1504
1506
+200V
1504
1506
1502
LOGIC CIRCUIT
1502
LOGIC CIRCUIT
1502
LOGIC CIRCUIT
1410
1500
SHIFT REGISTER
3RD SEGMENT
2ND SEGMENT
1ST SEGMENT
POLARITY
$\overline{OE}$
CLK
DATA

FIG. 14

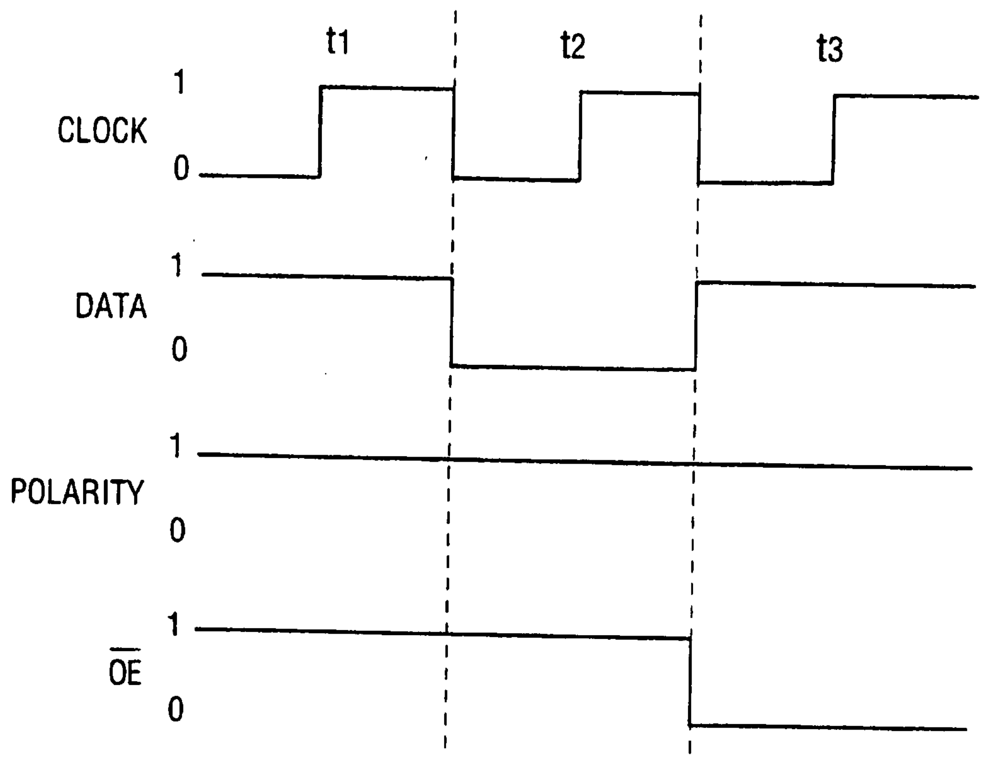
t1
t2
t3
CLOCK
1
0
DATA
1
0
POLARITY
1
0
$\overline{OE}$
1
0

FIG. 15

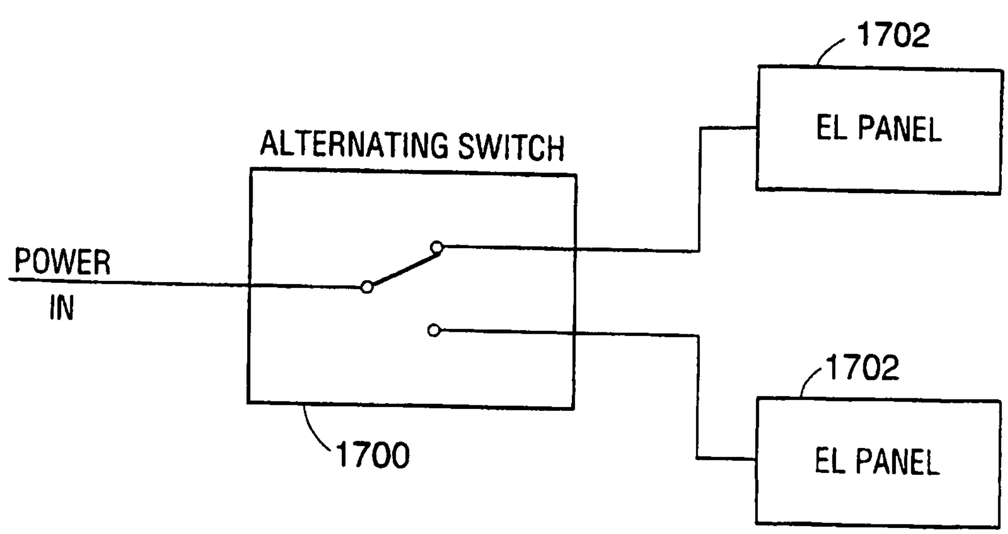
1702
ALTERNATING SWITCH
EL PANEL
POWER
IN
1702
1700
EL PANEL

FIG. 16

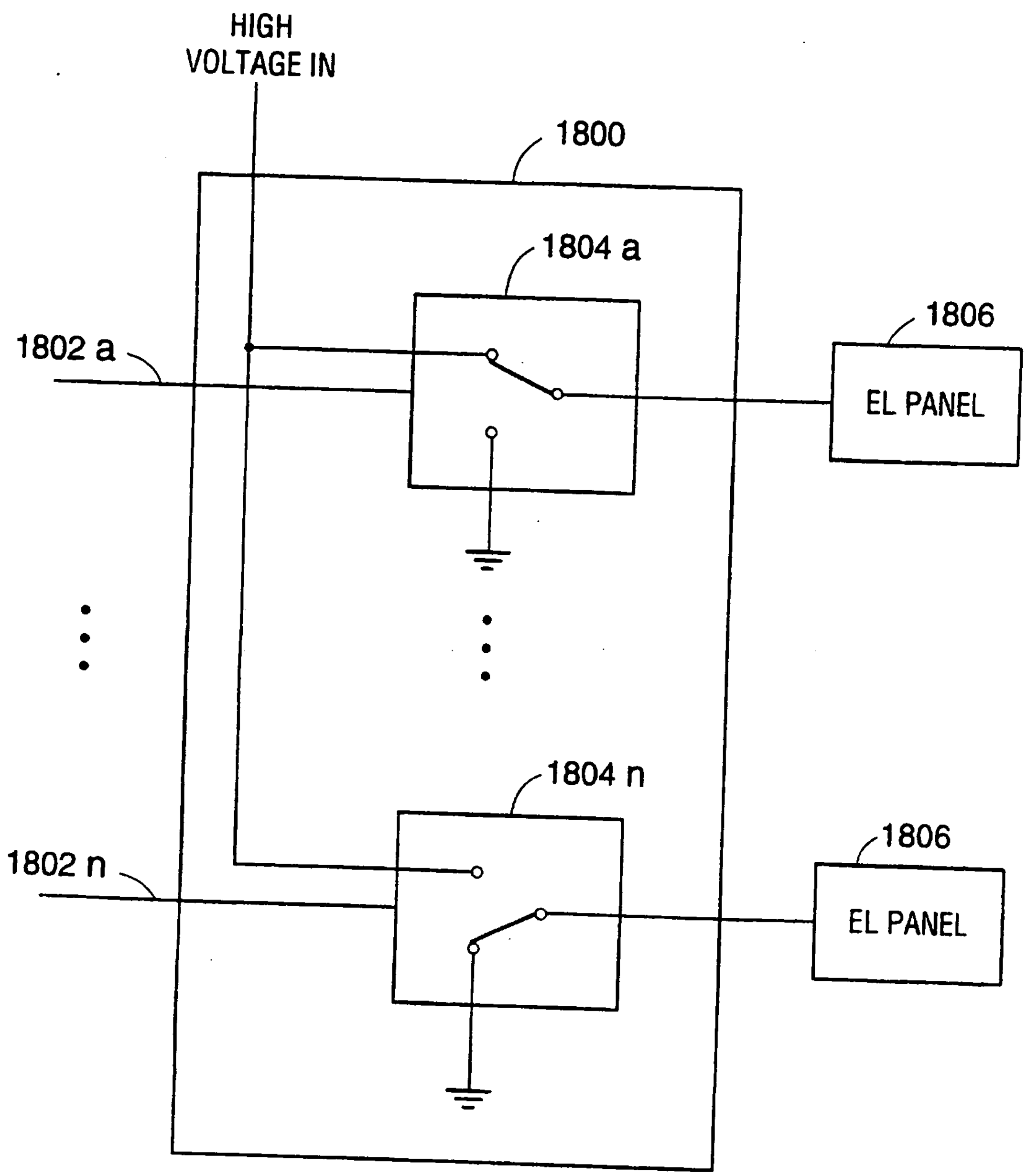
HIGH
VOLTAGE IN
1800
1804 a
1806
1802 a
EL PANEL
1804 n
1806
1802 n
EL PANEL

FIG. 17

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US97/01128

A. CLASSIFICATION OF SUBJECT MATTER
IPC(6) :G09G 3/30
US CL :345/76
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED
Minimum documentation searched (classification system followed by classification symbols)
U.S. : 345/76, 79, 1, 3, 209, 211; 315/169.3

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y	US, A, 5,359,341 (HUTCHINGS) 25 October 1994, col. 2 line 10 - col. 3 line 61.	1, 7-8, 13-14 --- 2-6, 9-12
Y	US, A, 5,336,978 (ALESSIO) 09 August 1994, col. 1 line 26 - col. 2 line 34.	2-3, 9-12
Y	US, A, 5,349,269 (KIMBALL) 20 September 1994, col. 2 lines 10-41.	4
Y	US, A, 5,093,654 (SWIFT ET AL) 03 March 1992, col. 8 lines 7 - 19.	5
Y	US, A, 5,293,098 (BROWNELL) 08 March 1994, figure 7.	6

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be part of particular relevance

"E" earlier document published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
26 MARCH 1997	16 APR 1997

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